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GCA Corp, Bedford, MA GCA Technology Div

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Standards of performance are proposed under authority of section 111 of the Clean Air Act to limit the emissions of volatile organic compounds (VOC) and trichloroethylene, perchloroethylene, methylene chloride, 1,1,1-trichloroethane, and trichlorotrifluoroethane from new, modified, and reconstructed facilities in which solvents are used to clean (degrease) metal, plastic, fiberglass, or any other type of material. The proposed standards would require new, modified, and reconstructed solvent cleaning facilities to use the best system of continuous emission reduction, considering costs, nonair quality health and environmental impacts, and energy impacts.

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Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

October 1979

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1. SUMMARY

1.1 PROPOSED STANDARDS

Standards of performance for new and modified organic solvent cleaners (degreasers) are being proposed under the authority of section 111 of the Clean Air Act. The emissions from these sources which would be controlled include volatile organic compounds as well as perchloroethylene, trichloroethylene, methylene chloride, trichlorotrifluoroethane, and 1,1,1-trichloroethane. Prior to proposal of these standards, the Administrator determined that emissions from organic solvent cleaners contribute to the endangerment of public health or welfare. In accordance with section 117 of the Act, proposal of the standards was preceded by consultation with appropriate advisory committees, independent experts, industry representatives, and Federal departments and agencies.

The proposed standards would reduce emissions of these five halogenated compounds and volatile organic compounds from cold cleaning degreasers, open top vapor degreasers, and conveyorized degreasers. The owner or operator of the affected faclity would be required to follow proper operating procedures and equipment specifications by degreaser type and size. The discussion that follows summarizes the proposed control equipment and operating requirements for each affected facility.

The control equipment for cold cleaners includes a cover, drainage racks or baskets, specified freeboard ratio, visible fill line, and a permanent label with operating requirements. Also, if a sprayer is used, a solid spray is required. In an electric agitation pump is used, rolling motions are required.

The operating requirements proposed for cold cleaners include closing of cover when degreaser is not in use, spraying parts inside of tank, time limit on drainage of parts, restriction of air agitation and waste solvent disposal requirements.

The control equipment for open top vapor degreasers includes a cover, safety switches and labels. All vapor degreasers must have a freeboard ratio equal to or greater than 0.75. Degreasers with a vapor-air interface area greater than one square meter are required to have either a refrigerated freeboard device or a lip exhaust connected to a carbon adsorber. However, for small degreasers with a vapor-air interface area of less than one square meter, these two devices are optional.

The operating requirements for open top vapor degreasers include all of the requirements for cold cleaners as well as specified work load moving rates, racking of parts, restricted work loads, vapor level restrictions, a properly operating water separator, and repairing of leaks.

The control equipment proposed for conveyorized degreasers includes refrigerated freeboard devices, carbon adsorption systems, drying tunnel and safety switches. The operating requirements for conveyorized degreasers include most of the requirements for open top vapor degreasers.

1.2 ENVIRONMENTAL IMPACT

The beneficial and adverse environmental impacts associated with the various control system alternatives that were considered are presented in this section. The impacts are discussed in detail in Chapter 7, Environmental Impact, and Chapter 8, Economic Impact. A matrix summarizing these impacts is included in Table 1-1. A cross reference between the EPA guidelines for the preparation of Environmental Impact Statements and this document is included in Appendix B.

Table 1-1. Matrix of Environmental and Economic Impacts of Alternative Standards

Administrative Action	Air Impact	Water Impact	Solid Waste Impact	Energy Impact	Noise Impact	Radiation Impact	Economic Impact	Inflation Impact
Proposed Standards	+3	-1	0	+1	0	0	+3	0
Delayed Standards	-3	+1	0	0	0	0	-3	0
No Standards	-3	+1	0	0	0	0	-3	0

+ Beneficial Impact
- Adverse Impact

0 No impact
1 Negligible Impact
2 Small Impact
3 Moderate Impact
4 Large Impact

The beneficial impacts on air quality are moderate for the proposed standards. There would be small adverse water quality impact from the wastewater from carbon adsorption control systems. A small beneficial energy impact would be associated with the proposed standards. There are no known noise or radiation impacts associated with the proposed standards.

1.3 ECONOMIC IMPACT

The costs associated with the proposed standards for new and modified organic solvent cleaners have been judged not to be of such magnitude to require an analysis of the inflationary impact. Many facilities would realize a net cost reduction due to implementation of the proposed standards.

Implementation of proper operating procedures and control devices would reduce solvent loss and minimize solvent expenditures. Control of open top and conveyorized vapor degreasers as well as manufacturing and maintenance cold cleaners would have a positive economic impact.
The cost of control for each affected equipment type on a per kilogram basis is given in section 8.2.

2. INTRODUCTION

Standards of performance are proposed following a detailed investigation of air pollution control methods available to the affected industry and the impact of their costs on the industry. This document summarizes the information obtained from such a study. Its purpose is to explain in detail the background and basis of the proposed standards and to facilitate analysis of the proposed standards by interested persons, including those who may not be familiar with the many technical aspects of the industry. To obtain additional copies of this document or the Federal Register notice of proposed standards, write to EPA Library (MD-35), Research Triangle Park, North Carolina 27711. Specify Organic Solvent Cleaners-Background Information: Proposed Standards, document number EPA-450/2-78-045 when ordering.

2.1 AUTHORITY FOR THE STANDARDS

Standards of performance for new stationary sources are established under section 111 of the Clean Air Act (42 U.S.C. 7411), as amended, hereafter referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution which ". . . causes or contributes significantly to air pollution which may reasonably be anticipated to endanger public health and welfare."

The Act requires that standards of performance for stationary sources reflect, ". . . the degree of emission limitation achievable through the application of the best technological system of continuous emission reduction . . . the Administrator determines has been adequately demonstrated." In addition, for stationary sources whose emissions result from fossil fuel combustion, the standard must also include a percentage reduction in emissions. The Act also provides that the cost of achieving the necessary emission reduction, the nonair quality health and environmental impacts and the energy requirements all be taken into account in establishing standards of performance. The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

The 1977 amendments to the Act altered or added numerous provisions which apply to the process of establishing standards of performance.

1. EPA is required to list the categories of major stationary sources which have not already been listed and regulated under standards of performance. Regulations must be promulgated for these new categories on the following schedule:

25 percent of the listed categories by August 7, 1980
75 percent of the listed categories by August 7, 1981
100 percent of the listed categories by August 7, 1982.

A governor of a State may apply to the Administrator to add a category which is not on the list or to revise a standard of performance.

2. EPA is required to review the standards of performance every four years, and if appropriate, revise them.

3. EPA is authorized to promulgate a design, equipment, work practice, or operational standard when an emission standard is not feasible.

4. The term "standards of performance" is redefined and a new term "technological system of continuous emission reduction" is defined. The new definitions clarify that the control system must be continuous and may include a low-polluting or non-polluting process or operation.

5. The time between the proposal and promulgation of a standard under section 111 of the Act is extended to ten months.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental impact and energy requirements.

Congress had several reasons for including these requirements. First, standards with a degree of uniformity are needed to avoid situations where some States may attract industries by relaxing standards relative to other States. Second, stringent standards enhance the potential for long-term growth. Third, stringent standards may help achieve long-term cost savings by avoiding the need for more expensive retrofitting when pollution ceilings may be reduced in the future. Fourth, certain types of standards for coal burning sources can adversely affect the coal market by driving up the price of low-sulfur coal or effectively excluding certain coals from the reserve base because their untreated pollution potentials are high. Congress does not intend for new source performance standards to contribute to these problems. Fifth, the standard-setting process should create incentives for improved technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under section 116 of the Act to establish even more stringent emission limits than those established under section 111 or those necessary to attain or maintain the national ambient air quality standards (NAAQS) under section 110. Thus, new sources may in some cases be subject to limitations more stringent than standards of performance under section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area which falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term "best available control technology" (BACT), as defined in the Act, means ". . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of 'best available control technology' result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to section 111 or 112 of this Act."

Although standards of performance are normally structured in terms of numerical emission limits where feasible, alternative approaches are sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(h) provides that the Administrator may promulgate a design or equipment standard in those cases where it is not feasible to prescribe or enforce a standard of performance. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions, high concentrations for short periods during filling, and low concentrations for longer periods during storage, and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

In addition, section 111(j) authorizes the Administrator to grant waivers of compliance to permit a source to use innovative continuous emission control technology. In order to grant the waiver, the Administrator must find: (1) a substantial likelihood that the technology will produce greater emission reductions than the standards require, or an equivalent reduction at lower economic energy or environmental cost; (2) the proposed system has not been adequately demonstrated; (3) the technology will not cause or contribute to an unreasonable risk to the public health, welfare or safety; (4) the governor of the State where the source is located consents; and that, (5) the waiver will not prevent the attainment or maintenance of any ambient standard. A waiver may have conditions attached to assure the source will not prevent attainment of any NAAQS. Any such condition will have the force of a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to three years to meet the standards, with a mandatory progress schedule.

2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Administrator to list categories of stationary sources which have not been listed before. The Administrator, ". . . shall include a category of sources in such list if in his judgement it causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow while adhering to the schedule referred to earlier.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. The approach specifies areas of interest by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these "areas" are actually pollutants which are emitted by stationary sources. Source categories which emit these pollutants were then evaluated and ranked by a process involving such factors as (1) the level of emission control (if any) already required by State regulations; (2) estimated levels of control that might be required from standards of performance for the source category; (3) projections of growth and replacement of existing facilities for the source category; and (4) the estimated incremental amount of air pollution that could be prevented, in a preselected future year, by standards of performance for the source category. Sources for which new source performance standards were promulgated or are under development during 1977 or earlier, were selected on these criteria.

The Act amendments of August 1977, establish specific criteria to be used in determining priorities for all source categories not yet listed by EPA. These are:

1) the quantity of air pollutant emissions which each such category will emit, or will be designed to emit;

2) the extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare; and

3) the mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source standards of performance.

In some cases, it may not be feasible to immediately develop a standard for a source category with a high priority. This might happen when a program of research is needed to develop control techniques or because techniques for sampling and measuring emissions may require refinement. In the developing of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category. Further, even late in the development process the schedule for completion of a standard may change. For example, inability to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources assigned.

After the source category has been chosen, determining the types of facilities within the source category to which the standard will apply must be decided. A source category may have several facilities that cause air pollution and emissions from some of these facilities may be insignificant or very expensive to control. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there may be no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by a standard of performance, not all pollutants or facilities within that source category may be covered by the standards.

2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost, and the nonair quality health and environmental impacts and energy requirements of such control; (3) be applicable to existing sources that are modified or reconstructed as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for development of standards is to identify the best technological system of continuous emission reduction which has been adequately demonstrated. The legislative history of section 111 and various court decisions make clear that the Administrator's judgement of what is adequately demonstrated is not limited to systems that are in actual routine use. The search may include a technical assessment of control systems which have been adequately demonstrated but for which there is limited operational experience. In most cases, determination of the ". . . degree of emission reduction achievable . . ." is based on results of tests of emissions from well controlled existing sources. At times, this has required the investigation and measurement of emissions from control systems found in other industrialized countries that have developed more effective systems of control than those available in the United States.

Since the best demonstrated systems of emission reduction may not be in widespread use, the data base upon which standards are developed may be somewhat limited. Test data on existing well-controlled sources are obvious starting points in developing emission limits for new sources. However, since the control of existing sources generally represent retrofit technology or was originally designed to meet an existing State or local regulation, new sources may be able to meet more stringent emission standards. Accordingly, other information must be considered before a judgement can be made as to the level at which the emission standard should be set.

A process for the development of a standard has evolved which takes into account the following considerations.

1. Emissions from existing well-controlled sources as measured.

2. Data on emissions from such sources are assessed with consideration of such factors as: (a) how representative the tested source is in regard to feedstock, operation, size, age, etc.; (b) age and maintenance of control equipment tested; (c) design uncertainties of control equipment being considered; and (d) the degree of uncertainty that new sources will be able to achieve similar levels of control.

3. Information from pilot and prototype installations, guarantees by vendors of control equipment, unconstructed but contracted projects, foreign technology, and published literature are also considered during the standard development process. This is especially important for sources where "emerging" technology appears to be a significant alternative.

4. Where possible, standards are developed which permit the use of more than one control technique or licensed process.

5. Where possible, standards are developed to encourage or permit the use of process modifications or new processes as a method of control rather than "add-on" systems of air pollution control.

6. In appropriate cases, standards are developed to permit the use of systems capable of controlling more than one pollutant. As an example, a scrubber can remove both gaseous and particulate emissions, but an electrostatic precipitator is specific to particulate matter.

7. Where appropriate, standards for visible emissions are developed in conjunction with concentration/mass emission standards. The opacity

standard is established at a level that will require proper operation and maintenance of the emission control system installed to meet the concentration/mass standard on a day-to-day basis. In some cases, however, it is not possible to develop concentration/mass standards, such as with fugitive sources of emissions. In these cases, only opacity standards may be developed to limit emissions.

2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires, among other things, an economic impact assessment with respect to any standard of performance established under section 111 of the Act. The assessment is required to contain an analysis of:

(1) the costs of compliance with the regulation and standard including the extent to which the cost of compliance varies depending on the effective date of the standard or regulation and the development of less expensive or more efficient methods of compliance;

(2) the potential inflationary recessionary effects of the standard or regulation;

(3) the effects on competition of the standard or regulation with respect to small business;

(4) the effects of the standard or regulation on consumer cost; and,

(5) the effects of the standard or regulation on energy use.

Section 317 requires that the economic impact assessment be as extensive as practicable, taking into account the time and resources available to EPA.

The economic impact of a proposed standard upon an industry is usually addressed both in absolute terms and by comparison with the control costs that would be incurred as a result of compliance with typical existing State control regulations. An incremental approach is taken since both new and existing plants would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the impact upon the industry resulting from the cost differential that exists between a standard of performance and the typical State standard.

The costs for control of air pollutants are not the only costs considered. Total environmental costs for control of water pollutants as well as air pollutants are analyzed wherever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made. It is also essential to know the capital requirements placed on plants in the absence of Federal standards of performance so that the additional capital requirements necessitated by these standards can be placed in the proper perspective. Finally, it is necessary to recognize any constraints on capital availability within an industry, as this factor also influences the ability of new plants to generate the capital required for installation of additional control equipment needed to meet the standards of performance.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decision-making process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performances for various industries, the Federal Courts of Appeals have held that environmental impact statements need not be prepared by the Agency for proposed actions under section 111 of the Clean Air Act. Essentially, the Federal Courts of Appeals have determined that ". . . the best system of emission reduction, . . . require(s) the Administrator to take into account counter-productive environmental effects of a proposed standard, as well as economic costs to the industry. . ." On this basis, therefore, the Courts ". . . established a narrow exemption from NEPA for EPA determination under section 111."

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969."

The Agency has concluded, however, that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, while not legally required to do so by section 102(2)(C) of NEPA, environmental impact statements are prepared for various regulatory actions, including standards of performance developed under section 111 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section is included in this document which is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are identified and discussed.

2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new source as ". . . any stationary source, the construction or modification of which is commenced . . ." after the proposed standards are published. An existing source becomes a new source if the source is significantly modified or reconstructed. Both modification and reconstruction are defined in amendments to the general provisions of Subpart A of 40 CRF Part 60 which were promulgated in the Federal Register on December 16, 1975 (40 FR 58416). Any physical or operational change to an existing facility which results in an increase in the emission rate of any pollutant for which a standard applies is considered a modification. Reconstruction, on the other hand, means the replacement of components of an existing facility to the extent that the fixed capital cost exceeds 50 percent of the cost of constructing a comparable entirely new source and that it be technically and economically feasible to meet the applicable standards. In such cases, reconstruction is equivalent to a new construction.

Promulgation of a standard of performance requires States to establish standards of performance for existing sources in the same industry under section 111(d) of the Act if the standard for new sources limits emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under section 108 or which has not been listed as a hazardous pollutant under section 112). If a State does not act, EPA must establish such standards. General provisions outlining procedures for control of existing sources under section 111(d) were promulgated on November 17, 1975, as Subpart B of 40 CFR Part 60 (40 FR 53340).

2.7 REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, section 111 of the Act provides that the Administrator ". . . shall, at least every four years, review and, if appropriate, revise . . ." the standards. Revisions are made to assure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive but will apply to stationary sources constructed or modified after the proposal of the revised standards.

3. THE ORGANIC SOLVENT CLEANING INDUSTRY

Extensive information concerning this industry is found in the EPA publication Control Techniques Guideline Document (CTG), Control of Volatile Organic Emissions from Solvent Metal Cleaning, (EPA-450/2-77-022).[1] The CTG is an integral part of the support package for this New Source Performance Standard. Information presented in this chapter supplements the CTG and contains additional data gathered since it was issued. The base year for data in the CTG and for this supplement is 1974.

3.1 GENERAL

Solvent cleaners can be divided into three major categories: cold cleaners, open top vapor degreasers, and conveyorized degreasers. Conveyorized degreasers use either vapor degreasing or cold cleaning. Although 1974 was used as a base year for these proposed standards, there have been changes within the organic solvent cleaning industry since then. Such changes include: the growing use of plastic autoparts or chrome-plated metal parts rather than painted metal parts; the hesitation to use or to expand organic solvent cleaning operations as a result of uncertainties with regard to regulations and the suspected carcinogenicity of some solvents; and the increased incidence of solvent substitution, particularly the practice of substituting 1,1,1-trichloroethane for trichloroethylene.[2,3,4] From projections of industry growth (see Chapter 8.1), it is estimated that in 1985 there will be 1,780,919 cold cleaners, 45,605 open top vapor degreasers, and 6,506 conveyorized degreasers (Table 8-6).

The consumption of solvents for degreasing in 1974 on a national basis is reported in Table 3-1. The estimated solvent consumption for degreasing in 1974 was 726 thousand metric tons (800 thousand short tons). This amount includes both halogenated and petroleum solvents (aliphatic and aromatic). Solvent use was 58, 28, and 14 percent for cold cleaning, vapor degreasing, and conveyorized (cold and vapor) degreasing, respectively.

Another estimate of total national degreasing solvent consumption for 1974 was 1.1 million metric tons (1.2 million short tons).[5] There was agreement with the CTG estimate for halogenated solvent consumption. Petroleum solvent consumption was estimated at 720,000 metric tons (790,000 short tons) compared with the less than 300,000 metric tons (330,000 short tons) estimated in the CTG. Petroleum solvent consumption includes solvents used in the maintenance cold cleaners found in small shops, and for wiping and spraying oversized items (where solvent is brought to the item to be cleaned). In the larger estimate of total solvent consumption, approximately 73 percent was for cold cleaning, 18 percent for open top vapor degreasing, and 9 percent for conveyorized degreasing.[1,5,6,7]

The data presented in the CTG are used for estimates made in this Background Information Document. In both estimates of solvent consumption for degreasing operations, more than half the total quantity of solvent was used in cold cleaners.

Table 3-1

National Degreasing Solvent Consumption[1] (1974)

Solvent Type	Solvent Consumption (10^3 metric tons)		
	Cold cleaning	Vapor degreasing	All degreasing
Halogenated:			
Trichloroethylene	25	128	153
1,1,1-trichloroethane	82	80	162
Perchloroethylene	13	41	54
Methylene Chloride	23	7	30
Trichlorotrifluoroethane	10	20	30
	153	276	429
Aliphatics	222		222
Aromatics:			
Benzene	7		
Toluene	14		
Xylene	12		
Cyclohexane	1		
Heavy Aromatics	12		
	46	0	46
Oxygenated:			
Ketones:			
Acetone	10		
Methyl Ethyl Ketone	8		
Alcohols:			
Butyl	5		
Ethers	6		
	29	0	29
Total Solvents:	450*	276**	726
Range of Accuracy:	(±125)	(±25)	(±145)

*Includes 25,000 metric tons from non-boiling conveyorized degreasers

**Includes 75,000 metric tons from conveyorized vapor degreasers.

3.2 LEVEL OF EMISSIONS FOR COLD CLEANERS

The CTG estimate of 1974 emissions of organic solvents from non-conveyorized cold cleaners is 380,000 metric tons (419,000 short tons). Cold cleaning accounts for almost all of the aliphatic, aromatic, and oxygenated degreasing solvents emitted nationally and for about one-third of the halogenated degreasing solvents emitted.[1] The CTG estimated that the average cold cleaning unit generally emits about 0.3 metric ton (0.33 short ton) per year of organics. About one-half to three-fourths of those emissions result from evaporation of the waste solvent at a disposal site.[1]

On the basis of estimates of both solvent consumption and number of cold cleaners, it was estimated in the CTG that in 1974 there was a total of 1.22×10^6 cold cleaners in use, of which 880,000 were maintenance cold cleaners and 340,000 were manufacturing cold cleaners.[1] The average manufacturing cold cleaner emits twice the amount of solvent as the average maintenance cold cleaner. The solvent emissions from maintenance and manufacturing cold cleaners were estimated in the CTG to be 0.25 and 0.50 metric ton (0.28 and 0.55 short ton) per unit per year respectively (Appendix B.2.2 in reference 1). This is equivalent to annual emissions of 220,000 and 170,000 metric tons (242,000 and 187,000 short tons) from maintenance and manufacturing cold cleaners, respectively. By this estimate, the national 1974 solvent emissions from cold cleaners amounted to 390,000 metric tons (429,000 short tons). On the other hand, emission tests performed on agitated cold cleaners indicated that about 0.06 kilogram (0.125 pound) of solvent is lost per hour.[10,11] A maintenance cleaner, operating an average of 2 hours per day for 260 days per year, would emit 0.30 metric ton (0.33 short ton) of solvent per year. Assuming that a manufacturing cold cleaner operates one full 8-hour shift per day, its annual emission would be 0.811 metric ton (0.89 short ton) of solvent. On the basis of these assumptions as well as the estimated number of each type of cold cleaner in 1974, bath evaporation would have resulted in the emission, in 1974, of about 26,000 and 40,000 metric tons (29,000 and 44,000 short tons) of solvents from maintenance and manufacturing cold cleaners, respectively. Additional emissions would have resulted from solvent carry-out and improper disposal of waste solvent. Bath evaporation accounts for 20 percent of solvent emissions from cold cleaners;[1] therefore, by this estimation, 330,000 metric tons (364,000 short tons) of solvent were emitted from cold cleaners in the United States in 1974.

3.3 LEVEL OF EMISSIONS FOR OPEN TOP VAPOR DEGREASERS

Five solvents are generally used in open top vapor degreasers (OTVD). These are: trichloroethylene, 1,1,1-trichloroethane, perchloroethylene, methylene chloride, and trichlorotrifluoroethane. National open top vapor degreaser emissions for these solvents was estimated to be 200,000 metric tons (220,000 short tons) in 1974.[1] For OTVD, the major types of emissions include diffusion and convection, solvent carryout, and waste solvent disposal. Unlike cold cleaners, most emissions occur due to diffusion and convection. This is because warm solvent vapors mix with air at the top of the vapor zone. This mixing increases with drafts and with disturbances from parts being moved into and out of the vapor zone. The solvent vapors thus diffuse into the room air and into the atmosphere.

Carryout losses are the liquid and vaporous solvent entrained on clean parts as they are taken out of the degreaser. There are five factors which directly effect the rate of carryout emission. They are:

- Porosity or absorbency of work loads,
- Size of work loads in relation to the degreaser's vapor area,
- Extent to which parts are allowed to drain after cleaning,
- Hoist or conveyor speeds, and
- Cleaning time in the vapor zone.

These factors are discussed further in Chapter 4.1.2 and the CTG.

Although the waste solvent evaporation from vapor degreaser sludge is usually less than the diffusion and carryout losses, it still contributes about 5 to 20 percent of the degreaser's total solvent emissions.[12] The volume of waste solvent in sludge from vapor degreasers is much less than that from cold cleaners for equivalent work loads. The reasons are two-fold. First, the solvent in the vapor degreaser sump can be allowed to become much more contaminated than the solvent used in a cold cleaner because the contaminants, with high boiling points, stay in the sump rather than vaporize into the cleaning zone. Second, since vapor degreasing solvents are halogenated, they are generally more expensive and are distilled and recycled to a greater extent than are cold cleaning solvents.

It is estimated that there will be 45,605 OTVD in operation in the United States in 1985 (see Table 8-6). Of these, approximately 19 percent will be regulated by this NSPS. Using vaporization, carryout, and waste solvent disposal emission factors for average OTVD, there would be an emission savings of 41,315 metric tons per year by 1985. This is based on data in section 8.2 which estimates uncontrolled emissions to be 11.3 metric tons per degreaser per year and controlled emissions to be 6.5 metric tons per degreaser per year.

3.4 LEVELS OF EMISSIONS FOR CONVEYORIZED DEGREASERS

According to the CTG[1] approximately 85 percent of conveyorized degreasers (CD) are vapor degreasers, leaving 15 percent as conveyorized non-boiling degreasers. It is estimated that conveyorized vapor degreasers (CVD) emit 25 metric tons of solvent per year per degreaser, whereas conveyorized cold cleaners (CCC) emit about 50 metric tons per year per degreaser. National emissions from all conveyorized degreasers was estimated to be 75,000 metric tons for CVD and 25,000 metric tons for CCC in 1974[1].

For an equivalent work load, solvent emissions are much less for conveyorized degreasers than for open top vapor degreasers. This is because of the small entrances and exits used with conveyorized degreasers.

As with an OTVD, solvent emissions for conveyorized degreasers are due to diffusion and convection, solvent carryout, and waste solvent disposal. Of these, carryout of vapor or liquid solvent contribute to the highest percentage of emissions. The factors that affect carryout are the drainage of cleaned parts and drying time. A drying tunnel, rotating basket, or equivalent method is essential for a CD since there is little an operator can do to reduce carryout from a poorly designed system.

Diffusion and convection can be reduced by minimizing the entrance and exit areas and by regulating the spray system.[13] Although these solvent bath emissions are not as great as carryout emissions, they are greater than waste solvent emissions. Methods of emission control for CD can be found in Chapter 4.2 and the CTG.

Evaporation due to waste solvent disposal is the smallest percentage emission from conveyorized degreasers. Waste solvent emissions from CD are generally less than 20 percent of the total CD emissions. This is because most conveyorized degreasers distill their own solvent. An external still is attached to the CD so that the solvent can be constantly pumped out, distilled, and returned to the sump. Wastes disposed from conveyorized degreasers usually include sump and still bottoms only.

3.5 REFERENCES

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8. Lapp, Thomas W., Betty L. Herndon, Charles E. Mumma, and Arthur D. Tippit. An Assessment of the Need for Limitations on Trichloroethylene, Methyl Chloroform, and Perchloroethylene. Draft Final Report (3 volumes) prepared by Midwest Research Institute for EPA, Office of Toxic Substances, EPA Contract 68-01-4121, September 15, 1977.

9. Data provided by Detrex Chemical Industries, Inc., Detroit, Michigan in correspondence from T.J. Kearny to J.C. Bollinger, of the EPA, dated February 16, 1976.

10. Information provided by the Kleer-Flo Company, Eden Prairie, Minnesota, in a presentation to the National Air Pollution Control Techniques Advisory Committee in San Francisco, California on November 3, 1976.

11. Data provided by the Twin City Testing and Engineering Laboratory, Inc., St. Paul, Minnesota in a laboratory test report to the Kleer-Flo Company, Eden Prairie, Minnesota on August 30, 1976.

12. "Trip Report - Meeting of ASTM Committee D-26 on Halogenated Organic Solvents, Gatlinburg, Tenn.," EPA Memorandum from J. L. Shumaker to D. R. Patrick, June 30, 1977.

13. A.S.T.M., D-26., "Handbook of Vapor Degreasing," A.S.T.M. Special Technical Publication 310A, Philadelphia, PA, April 1976.

4. EMISSION CONTROL TECHNIQUES

This chapter describes the devices which may be used to control emissions from the three types of organic solvent cleaners. A complete discussion of emission control techniques is found in the CTG.[1] Information presented in this chapter supplements the CTG and provides additional data gathered subsequent to its issuance. Control efficiencies are discussed in terms of percent emission reduction. In addition, operating procedures which affect solvent emissions are discussed. These procedures may be effective by themselves or in combination with control devices. Factors which affect the efficiency of these control measures are identified and discussed.

4.1 GENERAL

Levels of solvent emissions from cold cleaners, vapor degreasers, and conveyorized (cold or vapor) cleaners are discussed in Chapter 3. The four general sources of emissions which are common to all organic solvent cleaning equipment are: solvent bath evaporation, solvent carryout (drag out), ventilation exhaust, and waste solvent disposal.

A summary of emission control devices and procedures which may be used on each type of degreaser to control emissions from each source is presented in Table 4-1. The efficiencies of the control

Table 4-1. CONTROL TECHNOLOGY EVALUATION SUMMARY

Type of Degreaser	Type of Emission	Control Techniques		Efficiency of Control for the Particular Type of Emission	Reference
		Options	Procedures		
A. Cold Cleaner 1. Immersion or Dip	Bath evaporation	• Cover	• Closing cover except during loading and unloading	92%[2]	2
		• None, procedure only	• Air agitation not recommended		
	Solvent carry-out	• Drain racks or baskets	• Drainage time: 15 sec. minimum or until dripping ceases	50%[3]	3
2. Conveyorized	Ventilation	• Adsorber (carbon) followed by recovery	• Routine maintenance • Proper timing of regeneration cycles	60-90%[4]	4
		• Incinerator	• Maintaining proper air velocity in system	NA	
	Waste solvent disposal	• Distillation	• Use of appropriate still	>85% (vol.)	4
		• Solvent recovery service			
		• Landfill		NA	5
		• Incineration	• Maintaining proper air velocity in system	NA	
		• None, procedure only	• Proper solvent handling		
3. General	Solvent carry-out	• Drainage area within tank	• Drainage time: 15 sec. minimum or until dripping ceases	NA	1,4
	Ventilation	• Adsorber (carbon) followed by recovery	• Routine maintenance • Proper timing of regeneration cycles	60-90%	4
		• Incineration	• Maintaining proper air velocity in system		
		• None, procedures only	• Maintaining ventilation rate at minimum level to prevent unnecessary evaporation	NA	
			• Locating ventilation ductwork above the cover	NA	
	Waste solvent disposal	• Distillation	• Use of appropriate still	>85% (vol.)	4
		• Solvent recovery service		NA	
		• Landfill		NA	
		• Incineration	• Maintaining proper air velocity in system	NA	5
		• None, procedure only	• Proper solvent handling		
B. Open Top Vapor Degreaser	Bath evaporation	• Cover	• Keeping cover closed except when degreaser is in use	30-50%[4]	1,4
		• Enclosed design (door opens only when part enters or leaves)		NA	
		• High freeboard	• Use of freeboard ratio of 0.75 with all solvents	20-30%[a]	4,5,6
		• None, procedure only	• Minimizing drafts		

Table 4-1 (Continued). CONTROL TECHNOLOGY EVALUATION SUMMARY

Type of Degreaser	Type of Emission	Control Techniques		Efficiency of Control for the Particular Type of Emission	Reference
		Options	Procedure		
B. Open Top Vapor Degreaser (Continued)	Bath evaporation (Continued)	• Condenser flow switch and thermostat	• Turning off heat and closing cover when condenser coolant is not circulating or is too warm		
		• Vapor level control thermostat	• Avoiding excessive (shock) work loads that cause a vapor level drop in excess of 4 inches		1,5,6,7
		• Sump thermostat	• Periodic draining of used solvent, cleaning of degreaser, and solvent renewal		1,7
		• Solvent level control	• Maintaining sufficient solvent level in sump		1,7
		• Spray safety switch	• Spraying only below the vapor level		1,7
		• Water separator	• Routine maintenance program	NA	1,6
		• None, procedures only	• Repairing leaks; inspection and maintenance of system • Minimizing drafts		6
		• Drain racks	• Racking parts and tipping out pools of solvent before removal	NA	1,6,7
	Carry-out	• None, procedures only	• Moving parts through degreaser at less than 3.5 m/min		1,5,6,7
			• Degreasing work load in vapor zone at least 30 sec. or until condensation ceases		1,4,6
			• Drying for about 15 sec.		1
			• Keeping porous and absorbent materials from entering vapor zone		1,4
	Bath evaporation and carry-out	• Carbon adsorber		50-65%	1,4
		• Condensing coils • Refrigerated freeboard devices	• Monitoring temperature and flow of water following design specifications	30-40%[4] (cold traps)	1,4
	Waste solvent disposal	• Still	• Direct on-line distillation or contract reclamation service	Can recycle 80-85% of the solvent	1,6
		• Acceptable disposal technique; (special incinerators, landfills)	• Minimizing transfer and storage losses	NA	5,6
		• None, procedures only	• Maintenance program • Repairing leaks		

Table 4-1 (Continued). CONTROL TECHNOLOGY EVALUATION SUMMARY

Type of Degreaser	Type of Emission	Control Techniques		Efficiency of Control for the Particular Type of Emission	Reference
		Options	Procedures		
C. Conveyorized Degreaser	Bath evaporation	• Condensing coils and chillers	• Proper adjustment of primary cooling coils	NA	1
		• Entrance and exit area covers	• Closing cover when degreaser is not in use	NA	1,5
		• Water separator	• Routine maintenance	NA	1
		• Safety switches (same as vapor degreasers)			1
		• None, procedures only	• Avoiding overloading • Proper adjustment of the heat rate • Proper spray adjustment • Repairing leaks; system inspection and maintenance		1
	Carry-out	• Drain rack	• Providing for drainage	NA	
		• Drying tunnel	• Providing for proper drying	NA	
		• None, procedures only	• Conveyer speed less than 3.5-m/min		1,5,6
	Ventilation	• Carbon adsorption		20-60%^{b} 60-80%^{c}	4 4
	Waste solvent disposal	• Still (direct on-line or reclamation service	• Proper operation & maintenance • Proper disposal of still bottoms	>85%	1,4

NOTES: [a] This assumes 75:25 idle-to-operating time ratio and a carry-out equal to twice the diffusion rate with a 0.5 freeboard ratio and an air velocity between 0 and 30 m/min (0-100 ft/min).

[b] Efficiency of a carbon adsorber used in the exhaust system of a crossrod vapor degreaser.

[c] Efficiency of a carbon adsorber used in the exhaust of a monorail vapor degreaser.

NA = Data unavailable.

techniques are also listed. Some common factors which can influence the effectiveness of a control technique are:

- Solvent volume, type, volatility, temperature and concentration,
- Degreasing method, and
- Size of workload and duration of use.

4.1.1 Controls to Minimize Solvent Bath Evaporation

The principal devices for controlling solvent bath emissions are:

- Improved covers,
- High freeboards,
- Efficient condensing coils,
- Refrigerated freeboard devices
- Safety switches, and
- Water separators.

4.1.1.1 Improved Covers

A cover is one of the more effective control devices for an open top degreaser. The covers that are usually provided with open top degreasers often do not completely seal the opening or are too heavy for routine use. A sturdy, well designed cover which makes a good seal with the sides of the degreaser and which is easy to operate, provides the best deterrent to evaporation of the solvent from the bath. The different types of covers for degreasers are the hinged steel top, the plastic or canvas roll top, and the horizontal guillotine. While many open top degreasers (cold or vapor) are equipped with a cover, it can be an effective control only if it is used. A power-assisted cover may be advantageous depending on the size of the cover and the frequency of cover use.

Many conveyorized degreasers are covered. Improved covers at the work inlet and exit to the unit can be a factor in reducing emissions.

4.1.1.2 High Freeboards

The purpose of the freeboard is to reduce drafts at the solvent vapor/air interface for vapor degreasers, and at the solvent liquid/air interface for cold cleaners. The freeboard is the distance from this interface to the top of the degreasing tank. Freeboard height is expressed in terms of the freeboard ratio, that is, the ratio of freeboard height to degreaser width (not length).

Locating degreasers away from drafts will improve freeboard effectiveness, Care should be taken to prevent unnecessary drafts from heating, ventilation and air conditioning (HVAC) systems, and the opening and closing of doors. Baffles can be erected to further reduce drafts.

4.1.1.3 Condensing Coils

The function of a condensing coil is to limit the upper level of the vapor zone. A condenser, consisting of a coil of pipe through which cooling water flows, establishes a vapor level height. Hot solvent vapors and water vapor that are in the vapor zone condense on reaching the cool air. The condensate is collected and channeled to a separator to remove any condensed water and is then returned to the degreaser tank.

The factors which affect the efficiency of condensing coils are the heat input rate, the flow rate and temperature of the water, and the surface area of the coil. An efficient condenser will optimize the water flow and surface area for a specific solvent.

A degreaser operator must know the conditions necessary for the condenser to control the vapor level effectively. Degreasers should be equipped with devices to monitor and to adjust both the temperature and flow of the coolant.

4.1.1.4 Safety Switches

Safety switches are used on vapor degreasers to prevent emissions in case the degreaser malfunctions or the operator makes an error. The five main types of safety switches are:

- Vapor level control thermostat
- Condenser water flow switch and thermostat
- Sump thermostat
- Solvent level control
- Spray safety switch

The first four types of switches turn off the sump heat whereas the fifth turns off the spray. A description of these switches is found in the Control Techniques Guidelines document, section 3.1.1.5.[1]

There are a number of operating procedures which will control emissions and will obviate the conditions that activate the safety switches. These procedures are:

- Shutting off of the sump heat if the condenser coolant is not circulating or if it is too warm.
- Periodic draining of the used solvent, cleaning of the degreaser, and replenishment of the solvent.
- Maintaining solvent level in the sump.
- Spraying only below the vapor level.
- Repair of leaks.

The safety switches are used in emergencies. They do not replace proper degreaser maintenance and operation.

4.1.1.5 Water Separators

The purpose of a water separator is to remove the water which condenses with the solvent vapor so that pure solvent can be returned to the degreaser. Water contamination of a solvent can result in depletion of water-soluble stabilizers which can lead to breakdown of the solvent. The absence of a water separator or its failure increases evaporative emissions. Water returning to the surface of a boiling solvent sump can combine with the solvent to form an azeotrope which has a lower vapor density and is more volatile than the pure solvent.[6]

Routine maintenance is necessary for efficient operation of a water separator and to prevent emissions which would result from its failure.

4.1.2 Controls to Minimize Carryout (Drag Out)

Solvent carryout emissions are controlled primarily by using a drain rack or basket and by following good operating practices. The factors which influence the effectiveness of drain racks or baskets include drainage time, the size and shape of parts, and the drying method. The size of the work load relative to the degreaser's vapor area also affects drain rack effectiveness in controlling emissions.

Operating practices which limit carryout emissions are:

- Racking parts and tipping out pools of solvent before removal of the parts from the degreaser,
- Moving parts through the degreaser at speeds less than 3.3 m/min (10.8 ft/min),
- Drying parts in the freeboard area for about 15 seconds,
- Keeping the work load in the vapor zone of vapor degreasers at least 30 seconds or until condensation ceases.

Compressed air is sometimes used to dry cold cleaned parts. This practice increases emissions and should not be used. In addition, compressed air contains oil which would deposit on the parts being cleaned, thus defeating the purpose of degreasing. Instead, parts should be dried on drain racks.

4.1.3 Controls to Minimize Ventilation Emissions

Ventilation emissions can be controlled by use of a carbon adsorber and by proper operating practices. Carbon adsorbers are effective when used with properly designed ventilation systems. Such a system provides a flow input to the adsorber which allows the adsorber to operate efficiently. Ventilation systems include lip exhausts, spray booth exhausts, and overhead ventilators. Adsorbed solvent can be recovered through desorption techniques and can then be recycled to the degreaser. A carbon adsorber is estimated to be cost effective if at least three drums (55 gallons each) of solvent per week can be recovered.[8]

Poor operating practices lessen the efficiency of carbon adsorption systems. Examples of poor operating practices and conditions include inoperative dampers, the use of carbon that does not meet specifications, inappropriate timing of the desorption cycles, and excessive inlet flow rates. The carbon bed must be desorbed before the adsorption capacity of the bed is exceeded (breakthrough). Breakthrough occurs at a point well before saturation when the mass transfer zone reaches the end of the bed. If breakthrough occurs, solvent-laden air will be emitted. If desorption is performed too often, an energy penalty will be incurred.

The major factor affecting emissions from a carbon adsorber is the exhaust rate. The exhaust rate must be optimized to minimize degreaser emissions and to maximize adsorber collection efficiency. Too great an exhaust rate will increase emissions from an open top degreaser because the air/vapor interface is disturbed.

Additional information regarding ventilation emission control and other emission control alternatives may be found in the Control Techniques Guidelines Document.[1]

4.2 PERFORMANCE OF EMISSION CONTROL TECHNIQUES

This section discusses the performance of the emission control techniques delineated in Section 4.1 The supporting data for determining the emission control capability of each control technique are presented. The performance data, where available, are expressed in terms of percent emission control and are shown in Table 4-1 in the "Efficiency" column.

4.2.1 Peformance of Solvent Bath Evaporation Controls

4.2.1.1 Improved Covers

Covers on open top degreasers reduce total emissions greatly depending on the frequency of use of the cover.[1,4] Tests on cold cleaners have demonstrated that the efficiency of a cover in controlling bath evaporation losses can exceed 90 percent.[4] Emission reduction varies with solvent volatility, draft velocity, freeboard ratio, operating temperature, and degree of agitation.[1]

A closed cover is effective in reducing bath evaporation emissions from a degreaser. It is recommended that open top degreasers be covered whenever they are not used as well as between the loading and unloading of parts.[4,6] In addition, degreasers which are used intermittently should be covered during periods of disuse longer than half an hour.[4]

4.2.1.2 High Freeboards

EPA conducted tests to determine the effectiveness of freeboards on open top degreasers. The solvent used was 1,1,1-trichloroethane, and the degreaser was operated under moderate draft conditions. In the idling mode, control efficiencies were 27 and 55 percent when the freeboard ratio was increased from 0.50 to 0.75 and from 0.50 to

1.00, respectively. Control efficiencies of approximately 20 to 40 percent, respectively, were achieved during operation.[4] The effectiveness of the freeboard to control emissions is reduced during normal operations because of carry-out emissions. Other tests using the same solvent demonstrated that air flow rate and inlet water temperature to the top of the condenser determine the effectiveness of the freeboard.[9].

At a condenser temperature of 16°C (60°F), control efficiency for an open top vapor degreaser using trichlorotrifluoroethane solvent was 36 percent when the freeboard ratio was increased from 0.46 to 0.75.[10]

The effectiveness of freeboard height in controlling emissions from open top vapor degreasers varies with factors such as mode of operation, solvent used, work load area of the degreaser, condenser water temperature, and exhaust air flow rate. According to EPA's cold cleaner test reports, freeboard height has a significant effect on emissions when high volatility solvents such as halogenated organic compounds are used; however, freeboard height appears to have little effect on cold cleaner emissions when low volatility solvents such as mineral spirit are used.[2,3]

The American Society for Testing and Materials (A.S.T.M.) proposed standards for solvent metal cleaning operations recommends an effective freeboard ratio of 0.75 for open top vapor degreasers using halogenated solvents.[5]

4.2.1.3 Condensing Coil

Tests conducted on an open top vapor degreaser, using 1,1,1-trichloroethane, indicated that low water inlet temperatures reduce vapor loss.[9] Freeboard ratio and lip exhaust air flow influence the effectiveness of condensing coils.[9] At a given freeboard ratio, the effectiveness of this temperature difference in controlling emissions increases with decreasing air flow rates.[9] A decrease in the freeboard ratio lessens the effectiveness of lowering the condenser inlet water temperatures.[9]

4.2.1.4 Refrigerated Freeboard Devices

The control efficiency of refrigerated freeboard devices is between 35 and 60 percent when used with open top or conveyorized vapor degreasers.[4,11] These efficiencies depend on the type of secondary chiller (i.e., warm chiller (above 0°C) or cold chiller (below 0°C)), as well as operating conditions. The available test data documenting these efficiencies are presented in the CTG.

4.2.1.5 Safety Switches

At present, there are no adequate data to quantify the control efficiency of the vapor level control thermostat, condenser water flow switch and thermostat, sump thermostat, solvent level control switch, and spray safety switch. These switches are activated only as a result of improper degreaser operation. The inclusion of these devices in degreasers is recommended for safety considerations as well as for minimizing solvent emissions in the event of equipment failure or operator error.[4,6]

4.2.1.6 Water Separator

The emission control efficiency of a water separator is not known because very limited information is available. The need for a properly designed water separator is discussed in section 4.1.1.5. It is recommended that water separators be used with conveyorized degreasers and open top vapor degreasers.[1,6,12]

4.2.2 Performance of Controls to Minimize Solvent Carryout

The control efficiency of each of the techniques for minimizing solvent carryout, discussed in section 4.1.2, have not been determined. However, despite the lack of data regarding carryout, the techniques described are recognized by the industry as significantly reducing the solvent losses from this emission source.[1,4,5,6,13,14] The reason for this is that the techniques minimize the amount of solvent carried out of the degreaser by the parts being cleaned and its subsequent evaporation into the air.

4.2.3 Performance of Controls to Minimize Ventilation Emissions

Carbon adsorption systems, when used in conjunction with well designed ventilation systems, can achieve high levels of emission control. Theoretically, a carbon adsorber can capture more than 99 percent of the organic material input.[1] Because a ventilation system does not capture all of the solvent vapors and direct them to the adsorber, the actual tested reduction in emissions resulting from the use of carbon adsorption is 40 to 65 percent. Poor operating and maintenance practices can further decrease the control efficiency of a carbon adsorber. However, manufacturers of carbon adsorption systems estimate up to 85 percent solvent reduction through the use of carbon adsorption systems.[15]

These systems are satisfactory for the recovery of trichloroethylene, perchloroethylene, and fluorocarbon solvents. 1,1,1-Trichloroethane contains water soluble stabilizers. These stabilizers would normally be removed from the solvent in the steam condensate following carbon desorption. However, with a special stabilizer added to the adsorbent, 1,1,1-trichloroethane can also be recovered satisfactorily.[16] Methylene chloride emissions are also not usually controlled by carbon adsorption, due to a corrosion problem associated with steam stripping. The solvent dissolves large quantities of air which can lead to corrosion of the adsorber unit during the steam stripping process. Control efficiency data for carbon adsorbers are presented in the CTG.

4.2.4 Performance of Controls to Minimize Waste Solvent Emissions

Proper operating techniques, disposal methods, and reclamation equipment substantially reduce waste solvent emissions. Care in transferring, handling, and storing waste solvents sharply reduces the evaporative emissions from spills and from open storage containers. There are no data to express quantitatively the effectiveness of these operating techniques. Many of the emissions resulting from indiscriminate dumping of waste solvents on the ground or down the drain and from disposal of waste solvent can be reclaimed through distillation.[16,17]

As much as 95 percent of the halogenated solvents may be recovered from used solvents depending on the type of solvent and the distillation equipment used.[4,18] Waste solvent from cold cleaners can be handled by commercial reclamation services. One such company reported that it recycles about 75 percent of the solvent that it delivers for use in cold cleaners.[19]

4.3 REFERENCES

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5. American Society for Testing and Materials (ASTM), Committee D-26. Recommended Practice for New Source Performance Standards to Control Solvent Metal Cleaning Emissions.

6. American Society for Testing and Materials (ASTM), Committee D-26. Handbook of Vapor Degreasing. STP 310A, ASTM, Philadelphia, Pa. 1976.

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14. Baron-Blakeslee, Inc., Chicago, Illinois. Operating Instructions.

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16. Data provided by Dow Chemical Company, Midland, Michigan, in a telephone conversation between K.S. Suprenant and J. L. Shumaker of EPA/OAQPS, on January 11, 1977.

17. Data provided by Graymills Co., Chicago, Illinois, in a telephone conversation between F. X. Bar and J. L. Shumaker of EPA/OAQPS on January 13, 1977.

18. Detrex Chemical Industries, Detroit, Michigan, literature sheet No. IL 7505.5.

19. Data provided by Safety Kleen Co., Elgin, Illinois, in a letter to EPA, August 5, 1975.

5. MODIFICATION AND RECONSTRUCTION OF ORGANIC SOLVENT CLEANERS

5.1 BACKGROUND

Upon promulgation, New Source Performance Standards (NSPS) apply to all affected facilities which are constructed, modified, or reconstructed after the date of proposal of the standards. The sources regulated by the proposed standard are organic solvent cleaners (degreasers). The affected facility is the degreaser equipment and its ancillary components. Provisions applying to modification and reconstruction were published in the Federal Register on December 16, 1975 (40 CFR 58419).

Modification is defined as "any physical change in, or change in the method of operation of, an existing facility which increases the amount of any air pollutant (to which a standard applies) emitted into the atmosphere by that facility or which results in the emission of any air pollutant (to which a standard applies) into the atmosphere not previously emitted."[1] Reconstruction occurs when components of an existing facility are replaced to such an extent that:

(1) The fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility, and

(2) It is technologically and economically feasible to meet the applicable standards.[2]

There are certain circumstances under which an increase in emissions is not considered to be a modification. If a capital expenditure that is less than the most recent annual asset guideline repair allowance published by the Internal Revenue Service (Publication 534) is made to increase capacity at an existing facility which results in an increase in emissions to the atmosphere of a regulated pollutant, a modification is not considered to have occurred.

An increase in working hours (i.e., from one- to two-shift operation) or an extension from 8 to 10 hours per shift would also increase solvent emissions per day. This situation is also not a modification under the definitions set forth under 40 CFR 60.14(e)(3). A step-by-step approach to determining whether a physical or operational change constitutes a modification or reconstruction under the regulations is depicted in Figure 5-1.

5.2 POTENTIAL MODIFICATIONS

Some of the possible changes do not qualify by definition as modifications under 40 CFR 60.14. They are, however, potential causes of increased solvent emissions and are therefore discussed in this section.

5.2.1 Routine Maintenance, Repair, and Replacement

Maintenance, repair, and component replacement which are considered routine for a source category are not considered modifications under section 60.14(e)(1). An increase in emissions is not expected to occur as a result of normal maintenance, repair, or replacement of degreaser components.

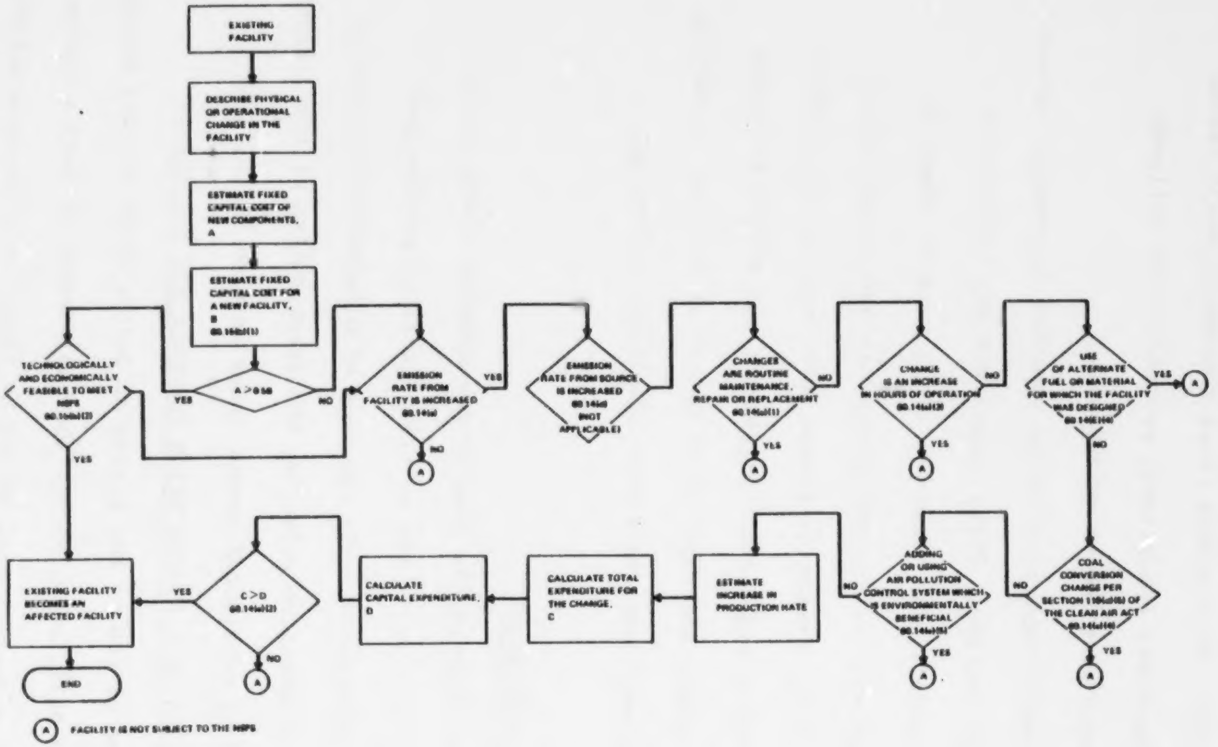
EXISTING FACILITY
DESCRIBE PHYSICAL OR OPERATIONAL CHANGE IN THE FACILITY
ESTIMATE FIXED CAPITAL COST OF NEW COMPONENTS, A
ESTIMATE FIXED CAPITAL COST FOR A NEW FACILITY, B 60.15(b)(1)
A > 0.5B
YES
NO
TECHNOLOGICALLY AND ECONOMICALLY FEASIBLE TO MEET NSPS 60.15(b)(2)
YES
EMISSION RATE FROM FACILITY IS INCREASED 60.14(a)
YES
NO
EMISSION RATE FROM SOURCE IS INCREASED 60.14(d) (NOT APPLICABLE)
CHANGES ARE ROUTINE MAINTENANCE, REPAIR OR REPLACEMENT 60.14(e)(1)
NO
YES
CHANGE IS AN INCREASE IN HOURS OF OPERATION 60.14(e)(3)
NO
YES
USE OF ALTERNATE FUEL OR MATERIAL FOR WHICH THE FACILITY WAS DESIGNED 60.14(e)(4)
YES
NO
COAL CONVERSION CHANGE PER SECTION 119(d)(5) OF THE CLEAN AIR ACT 60.14(e)(4)
NO
YES
ADDING OR USING AIR POLLUTION CONTROL SYSTEM WHICH IS ENVIRONMENTALLY BENEFICIAL 60.14(e)(5)
NO
YES
ESTIMATE INCREASE IN PRODUCTION RATE
CALCULATE TOTAL EXPENDITURE FOR THE CHANGE, C
CALCULATE CAPITAL EXPENDITURE, D
C > D 60.14(e)(2)
YES
NO
EXISTING FACILITY BECOMES AN AFFECTED FACILITY
END
A
Ⓐ FACILITY IS NOT SUBJECT TO THE NSPS

Figure 5-1. Method of Determining Whether Changes to an Existing Facility Constitutes a Modification or Reconstruction under 40 CFR 60.14 and 60.15

Routine maintenance would involve cleaning out a degreaser, water jacket, condenser coils and heater element (in the case of vapor degreasers), a still, valves and transfer lines, and lubricating pumps and motors. Maintaining these components would lessen emissions, assuming proper operational procedures are followed. Repairing leaks would also lessen emissions.

Several degreaser components can be expected to require replacement as a matter of routine. These components may include the heating coil or elements, the condenser coil, a valve, pump, or motor. Replacement with equivalent components should not affect emissions and would be considered exempt under section 60.14(e)(1). Similarly, the routine replacement of solvent and activated carbon (for an existing carbon adsorber) would not be considered a modification if the replacement materials were identical in type and quantity.

5.2.2 Alternative Solvents

The use of an alternative fuel or raw material would not be considered a modification if the existing facility was designed to accommodate the alternative. In the case of a degreaser originally designed to use alternative solvents, the substitution of the alternative solvent(s) would be considered exempt under section 60.14(e)(4).

5.2.3 The Addition of a System Which Controls Air Pollutants

The addition or use of any system or device whose primary function is to reduce air pollutants, except the replacement of such a system or device by a less efficient one, is not by itself considered a modification under section 60.14. For example, the addition of a carbon adsorption system to an existing degreaser for the purpose of reclaiming valuable solvent that would otherwise be emitted to the atmosphere would not be considered a modification under section 60.14(e)(5).

5.2.4 Increase in Production Rate Without a Capital Expenditure

An increase in production rate of an existing facility is not in and of itself a modification under section 60.14 if the increase can be accomplished without incurring a capital expenditure.

Degreasers are generally rated for maximum recommended work throughput. It is possible for a degreaser user to increase the amount of work being degreased by using the unit more of the time. This increase in the work rate would not be considered a modification under section 60.14(e)(2). If the need for increased capacity requires a capital expenditure to modify the degreaser, then that degreaser would be considered a modification under this section.

5.2.5 Equipment Relocation

Relocation of a degreaser within the same plant does not constitute a modification.

5.2.6 Removal or Disabling of a Control Device

The removal of a cover or the disabling of the closure mechanism on an existing facility constitutes a modification. Further, the intentional disabling of any emission control component of an existing degreaser system which would cause an increase of emissions is a modification. An existing facility which is modified becomes an affected facility under the NSPS.

5.3 RECONSTRUCTION

5.3.1 Replacements Deemed to be Reconstruction

Degreasers are expected to last up to 30 years with vapor degreasers requiring replacement at 20 to 30 years and large conveyorized degreasers at 30 years.[3] Major reconstruction is not generally undertaken except for large, complex, custom-designed, conveyorized systems.[4] The examples which follow illustrate conditions under which an affected facility may be considered to be reconstruction according to section 60.15.

When a refrigerated freeboard device is replaced at a cost in excess of 50 percent of the cost of a new facility, the degreaser would, unless exempted elsewhere, be considered a reconstructed facility under Section 60.15 (a) and (b). The rebodying of a degreaser, although rarely done, could cost more than 50 percent of the capital cost of a new degreaser; the affected facility must then comply with the standard. The replacement of a gas-fired or steam heater in a degreaser by an electric heating system may cost in excess of 50 percent of a new degreaser, especially if extensive electrical service installation is required; this would constitute reconstruction under section 60.15.

5.3.2 Technical Infeasibility Precluding Compliance

The following example illustrates a reconstruction for which it would be technologically infeasible to meet the applicable standard.

A large degreaser may be rebuilt at a substantial cost and may be located along an assembly line with limited space. It may not be possible to provide control equipment as specified in the NSPS because of lack of space. Steam may also be needed for use with a carbon adsorber at a location which does not have facilities for providing steam, and the plant cannot be modified to provide it. Under these conditions, reconstruction may be considered not to have occurred because it is technologically infeasible to meet the applicable NSPS.

5.4 REFERENCES

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4. Data provided by Detrex Chemical Industries, Inc., Detroit, Michigan, in a telephone conversation between L. Schlossberg and Gerald R. Goldgraben of The MITRE Corporation, Metrek Division, on May 18, 1978.

6. SELECTED EMISSION CONTROL SYSTEMS

This section delineates emission control equipment and required operating practices that constitute emission control systems for degreasers. The organic solvent cleaning industry utilizes a range of equipment types, sizes, and operating techniques. Therefore, no one emission control technology and no single set of operating practices apply to the entire industry. A set of equipment types and sizes representative of those currently in use is set forth. Each of these will be described. Emission controls and operating practices will be defined for each.

6.1 COLD CLEANERS

6.1.1 Emission Control Options for Cold Cleaners

All cold cleaners (CC) should be equipped with covers which can be readily closed. Fusible links may be used to actuate closing in the event of fire. All CC should be equipped with an interior or exterior drain rack. For the latter, drained solvent should be routed back to the tank. The exterior drain rack need not be covered. If a parts basket is used, interior hooks which suspend the basket above the solvent level will serve as a replacement for the interior drain rack. All CC should have a freeboard ratio of at least 0.7 if the solvent volatility is greater than or equal to 4.3 kPa (33 mm Hg or 0.6 psi) measured at 38°C. For solvents with a volatility of less than 4.3 kPa measured at 38°C, a freeboard ratio of 0.5 will suffice.

All CC should be equipped with a visible internal fill line above which they should not be filled. Finally, a conspicuous label should be permanently affixed near to all CC on which the recommended operating practices are clearly stated.

If a CC is equipped with a cleaning wand, the pump should not deliver the solvent at greater than ten psi measured at the pump outlet. Solvent should be delivered in a solid stream and not as a droplet spray. If a CC is equipped with an electric pump for solvent agitation, the pump should only be large enough to produce a rolling motion of the solvent. In no case should the pump be so powerful as to produce observable splashing of the solvent against tank walls or parts being cleaned when the solvent level is at the fill line.

6.1.2 Operating Practices for Cold Cleaners

Solvent is lost to the environment from cold cleaning operations by four main routes: spillage during solvent transfer, vaporization of solvent from the open tank, carryout of solvent on cleaned parts, and losses from improper waste solvent disposal. The operating practices defined in this section will reduce solvent loss from the first three of these sources. Methods of reducing losses from waste solvent disposal include solvent recovery, incineration, and proper landfilling.

Cold cleaners should be covered when not in use and also when parts are being cleaned by solvent agitation. If the CC is equipped with an air agitator, the air flow should not be so large as to produce visible entrainment of droplets above the solvent surface when the tank is filled to the normal level. Spraying should always be performed within the tank and not in the exterior solvent drain tray. Cold cleaners when uncovered should not be exposed to steady drafts greater than 40 m/min (131 ft/min) above the tank lip. Drafts may be controlled by enclosures or screens. After the cleaned parts are removed from the solvent and spraying has been completed, the parts should be allowed to drain until dripping has stopped. It has been demonstrated that the amount of solvent drained in the initial 15 seconds ranged from 75 to 97 percent of the total solvent drained in 30 seconds. If the parts have cavities or blind holes, the parts should be agitated or rotated during the drain period.

Dirty solvent should be kept in covered containers. Dripping drain taps and cracked cover gaskets should be replaced or repaired, and tank leaks should be repaired immediately. Solvent spilled during transfer should be wiped up promptly, and the wipe rags should be stored in a closed container.

6.1.3 Expected Reductions in Emissions from Cold Cleaners

The magnitude of the losses from a CC depends on the solvent and the workload. For volatile solvents and a heavy workload which requires that the cover be off much of the time, vaporization losses will exceed carryout losses. For less volatile solvents and a light workload, the reverse may be true. The expected reductions will therefore be derived for the representative CC that is described in Table 6-1. For this CC, the uncontrolled solvent losses from vaporization and carryout are 430 and 74 kg/year respectively. If a 30-second solvent drain time is allowed before parts removal and if the CC is covered for all but the two hours per day during which it is in use, then the controlled emissions by vaporization and carryout are 64 and 36 kg/year. The control efficiency of a cover is 84 percent in reducing vaporization losses and that of a properly operated drain rack is 50 percent in reducing carryout. The combined efficiency of both controls in reducing emissions from bath evaporation and solvent carry-out is 79 percent.

Good operating practices are essential in reducing solvent losses from CC since almost all cold cleaners are operated manually. Therefore, if covers are not replaced on cold cleaners when they are not in use and/or if parts are removed from the drain racks too soon, the 79 percent reduction in emission will not be obtained. If a CC equipped with a solvent agitator is left open during agitation, increased solvent vaporization losses will decrease the efficiency of a cover from 84 percent to 49 percent. Care should be exercised during solvent transfer operations in order to reduce solvent loss through spillage. If the solvent is changed six times yearly in the representative CC,

Table 6-1. DESCRIPTION AND OPERATING CONDITIONS FOR REPRESENTATIVE COLD CLEANER

Area	0.4[2]
Solvent	39°C (102°F) flash point mineral spirits
Airflow	12 m/min (39 ft/min)
Freeboard ratio	0.6
Operating time	2 hrs/day, 5 days/week
Loads/day	20
Evaporation[1]	118 g/hr-m^2
Carryout[1] (30-sec drain)	7 g/load
Carryout* (5-sec drain)	14.2 g/load
Cover efficiency[2] (when cover is in place)	90%

*Calculated from Tables 2 and 4 in Reference 1.

a 10 percent uncontrolled loss during each transfer will double the solvent emissions. Evaporative losses are proportional to draft velocity. Location of the CC in a 64 m/min (210 ft/min) draft would increase solvent emissions by 152 percent over a draft velocity of 23 m/min (92 ft/min).[3]

6.2 OPEN TOP VAPOR DEGREASERS

Open top vapor degreasers (OTVD) are manufactured in a much greater range of sizes than are cold cleaners. Production OTVD are available in sizes ranging from 0.2 to 4.5 square meters (2 to 48 square feet), and much larger custom-built models are also in use.[4] Different sets of control technology options are applicable to models of substantially different sizes. In addition, the relative efficiency of the control technology options will depend on the fraction of time that the OTVD is uncovered and processing work.

6.2.1 Control Equipment Options for Open Top Vapor Degreasers

The major sources of solvent emissions from OTVD are diffusion of solvent vapor and carryout of solvent on the parts which have been cleaned. In this respect, OTVD are similar to cold cleaners. For the OTVD, carryout can only be minimized by proper operating procedures, since there is no technology to control this loss. However, there are a number of existing control technologies which will reduce vaporization losses.

It has been estimated that the typical OTVD is heated but not in use about 75 percent of the operating day.[5] An effective cover will reduce vaporization by 90 percent during these periods. For a small OTVD, manually operated covers are generally used. Covers on larger OTVD can be powered or equipped with spring assists. Many OTVD are being manufactured with a roll-up cover as standard or optional equipment. A few large OTVD, manufactured for pipe degreasing, are equipped with sliding guillotine covers.

Increasing the freeboard ratio decreases vaporization losses from uncovered OTVD, particularly if drafts of more than 30 m/min (98 ft/min) are present. Refrigerated freeboard devices which provide an additional layer of cool air above the vapor-air interface are also effective in reducing vaporization losses.

For a production OTVD which operates at a high workload, the most effective emission control is a lip exhaust connected to a carbon adsorber. The cover should be located below the lip exhaust. A lip exhaust should not be used by itself since the increased disturbance of the air-vapor interface can double the solvent vaporization rate.[5]

Vaporization losses during transfer of hot or warm contaminated solvent from the OTVD sump should be controlled by using threaded or other leak-proof couplers. The contaminated solvent should be transferred to a vented tank which can be sealed after transfer is complete. Sump and still bottoms should be kept in sealed containers. A visible label on which required operating practices are clearly stated should be clearly visible to all OTVD operators.

6.2.2 Operating Practices for Open Top Vapor Degreasers

Operating practices for an OTVD are of two types: those designed to minimize vaporization or disturbance of the air-vapor interface and those which will minimize solvent carryout.

The first group includes a number of different operating practices. The OTVD should always be covered when parts are not being degreased. The OTVD should not be exposed to steady drafts greater than 40 m/min (131 ft/min) over the lip. If the OTVD is equipped with a lip exhaust, the exhaust should be turned off when the degreaser is covered. Work being degreased should not occupy greater than 50 percent of the area of the air-vapor interface. The OTVD should not normally be overloaded so as to cause the air-vapor interface to drop more than 10 cm (4 inches) when the work is lowered into it. However, in certain specific solvent vapor degreasing operations, where, of necessity, very large masses must be degreased at one time (e.g., large castings and fabricated assemblies), the air-vapor interface may unavoidably drop more than 4 inches. In such situations, the manufacturer of the equipment and the user of the equipment should attempt to reduce this problem as much as possible through equipment design, rate of work introduction and withdrawal, and other operating practice modifications. If a powered hoist is used, vertical speeds should not exceed 3.3 m/min (10.8 ft/min) when lowering and raising the parts being degreased. Spraying operations should be done within the vapor layer, and work should not be lifted from the vapor until condensation has stopped. When starting up a cold OTVD, the condenser water should be turned on before the sump heater. This process should be reversed on shutdown, and condenser water flow should be maintained until the vapor layer collapses.

The second group of operating practices minimizes solvent carryout. If parts are sprayed or rinsed in a warm sump prior to the final vapor degreasing, the work should not be removed from the vapor until visible condensation or dripping has stopped. Parts having recesses or blind-holes should be rotated or agitated prior to being removed from the vapor layer. Porous or absorbent materials should not be degreased. Water should not be visible in the solvent stream from the water separator. Visible leaks, cracked gaskets, and malfunctioning pumps, water separators, and steam traps should be repaired immediately.

6.2.3 Reduction in Emissions from Open Top Vapor Degreasers

The set of emission control technologies that is appropriate for each particular OTVD depends on the size and workload of that OTVD. Covers will be more effective in reducing emissions from degreasers which are hot but idle most of the time than from those which have a heavy workload requiring them to be uncovered much of the time. Lip exhausts connected to carbon adsorbers are generally the most effective controls.

The efficiency of each of the various control technology options in reducing vaporization losses has been estimated although precise experimental data are lacking. The probable effectiveness of controls in reducing vaporization losses of trichloroethylene from any size OTVD is tabulated in Table 6-2.

TABLE 6-2. PERCENTAGE REDUCTION IN VAPORIZATION LOSSES

Control Technology	Reduction (%)
Freeboard ratio (FR) increased to 0.75 from 0.5 (50 ft/min draft)	27[5]
Refrigerated freeboard device	40[6]
Lip exhaust and carbon adsorber	65[7]
Cover (when in place)	90[3]

Since no single set of emission controls can be specified for all OTVD, a representative set of degreasers and operating scenarios has been selected (see Table 6-3).

TABLE 6-3. OPERATING CONDITIONS FOR REPRESENTATIVE OTVD

	Size of OTVD		
	Small	Medium	Large
Fraction of time idle	0.75	0.50	0.25
Shifts in use per day	1	2	3
Vapor-air interface area (m^2)	0.8	1.67	5.0

In order to estimate the effectiveness of various control technology options for OTVD, calculations were based on the representative units described in Table 6-3 and on the following assumptions: vaporization is taken as 1.82 kg/m^2-hr (0.373 lb/ft^2-hr) when the OTVD is hot and uncovered[5] and carryout is assumed to be 1.5 kg/m^2-hr (0.3 lb/ft^2-hr) when the degreaser is hot and active[8]. The uncontrolled losses are based on an uncovered OTVD with FR = 0.5. The controlled losses assume use of a cover when work is not being processed as well as the designated emission control equipment. The estimated reductions in emissions due to vaporization losses are presented in Table 6-4.

TABLE 6-4. REDUCTIONS IN VAPORIZATION LOSSES

	OTVD size		
	Small	Medium	Large
Control technology	FR = 0.75	Refrigerated freeboard device	Lip exhaust and adsorber
Reduction due to control (%)	6.2	14.9	15.2
Reduction due to cover (%)	61.0	34.8	32.2
Total emission reduction (%)	67.2	49.7	47.4

As with cold cleaners, these reductions in vaporization losses require the continual implementation of the recommended operating practices. As far as possible, OTVD should not be exposed to drafts since doubling the airflow (from 15.3 m/min) more than doubles vaporization losses.[9]

6.3 CONVEYORIZED DEGREASERS

There are two types of conveyorized degreasers (CD): conveyorized vapor degreasers (CVD) and conveyorized cold cleaners (CCC). The latter use halogenated solvent for cleaning printed circuit boards. Both types of CD are used almost exclusively for production work. The CD are often enclosed and are thereby more protected from drafts than OTVD.

6.3.1 Control Equipment Options for Conveyorized Degreasers

There are two major emission control technologies for CVD: carbon adsorption and refrigerated freeboard devices. With adsorption, an exhaust fan draws the solvent-air mixture from the CVD and passes it through a bed of activated carbon. At intervals, the bed is desorbed, usually with steam; the solvent-water mixture is then passed through a separator, and the recovered solvent is returned to the CVD. The refrigerated freeboard device on a CVD functions in the same way as one on an OTVD. An inversion layer is created which decreases the migration of solvent vapor through the cold air layer.

Carryout losses from a CVD may be reduced by using a drying or a downdraft tunnel, depending on the type of degreaser[10], coupled to a carbon adsorber. Circuit board CCC also normally convey the flat boards on mesh belts. Solvent carryout can be reduced with soft rollers which physically wipe the solvent from the board.

The loss of vapor by convection or diffusion from the entry and exit ports of a monorail CVD can be reduced by decreasing the port area. Silhouette cutouts or hanging plastic or rubber flaps are effective. Mesh belt circuit-board cleaners normally have small port areas so cutouts are not very effective, particularly if cold solvent is used. Downtime covers will minimize vaporization losses during cooling; they will also reduce cold solvent vaporization losses from CCC and from idle CVD.

6.3.2 Operating Practices For Conveyorized Degreasers

Conveyorized degreaser work speeds are usually fixed. Cross-rod CVD are often equipped with baskets which rotate, thereby decreasing solvent carryout in blind holes and cavities, and with sprays that are fixed below the vapor zone.

There are several operating practices that would significantly reduce solvent emissions from CD. Belt or rod speeds should be kept at or below 3.3 m/min (10.8 ft/min) for all degreasers by proper gearing of electric motor drives. Spraying should take place within the vapor layer. If silhouette cutouts are used on monorail degreasers, they should be changed for each new run of parts whenever possible in order to maintain silhouette clearance at 10 percent or less of the entrance or exit opening. Condenser water should be turned on before the sump heater at startup, and water flow should be maintained after shutdown until the vapor layer has collapsed. Downtime port covers should be positioned immediately after sump heat has been shut off.

Solvent concentrations in the carbon adsorber exhaust should be monitored continuously by automatic equipment to check for malfunctions or solvent breakthrough in the adsorber bed. The carbon adsorber should not be bypassed during desorption. Leaks should be repaired immediately. Sump drainage and transfer of hot or warm solvent should be carried out using threaded or other positive couplings. Both clean and contaminated solvent should be stored in closed containers.

6.3.3 Reduction in Emissions from Conveyorized Degreasers

Investigations of the use of carbon adsorbers on conveyorized degreasers show an effective 95 percent recovery of solvent from the air by the adsorber bed.[10] Vaporization losses from CVD are generally less than those from OTVD by a factor of three.[11] In addition, the inlet air will dry parts and reduce carryout if an adsorber is used. There are no data to indicate the relative reductions in vaporization and carryout emissions, but two major manufacturers of carbon adsorbers will guarantee 50 percent reduction in total solvent usage.[12] Solvent recovery has been estimated at 85 percent for monorail CVD and 60 percent for crossrod CVD.[13] A 60 percent reduction was achieved for a circuit-board cleaner.[10] The estimated reductions in total solvent emissions that can be effected by a properly installed carbon adsorber are given in Table 6-5.

No reliable data are available on emission reductions from a freeboard chiller on a CVD. One test showed a 65 percent emission reduction, but these data are suspect since the CVD exhaust was turned on when the refrigerated freeboard device was off.[15] It is known that increasing exhaust velocities significantly increases vaporization losses.[5,9] Because a refrigerated freeboard device used on a CVD is not exposed to drafts, they are usually more efficient than an OTVD of the same area. One manufacturer estimates that a refrigerated freeboard device installed on a crossrod CVD will reduce total emissions by 40 percent.[16]

TABLE 6-5. REDUCTION IN TOTAL SOLVENT EMISSION EFFECTED BY CARBON ADSORBERS

Degreaser Type	Reduction(%)
Crossrod	50[12]
Monorail conveyer	60[12]
Monorail and drying tunnel	70[14]
Circuit board cleaner	60[10]

The use of downtime covers will reduce emissions by 3 to 6 percent on a CVD that is operated for one shift per day. The savings are negligible for a CVD that is operated for three shifts daily. Silhouette ports which decrease open area by 50 percent can reduce vaporization losses by approximately 10 percent if no other control technology is used. Emission reduction is negligible if only a carbon adsorber is used and amounts to about 5 percent if only a refrigerated freeboard device is used.

6.4 WASTE SOLVENT DISPOSAL OPERATIONS

Disposal of waste solvent from all organic solvent cleaning operations (new and old) would be regulated by the Resource Conservation and Recovery Act (RCRA). Any additional requirements imposed by this NSPS would not cause an incremental increase to the amount of waste solvent disposed.

6.4.1 Regulation by the Resource Conservation and Recovery Act

These regulations define halogenated and non-halogenated solvents and solvent recovery still bottoms as hazardous wastes. Under RCRA, waste solvent, sump, and still bottoms may be disposed of by distillation, incineration, landfilling, or storage in surface impoundments or basins. Distillation is the preferred method for the control of waste solvent because it recycles the waste solvent thereby conserving energy. Approximately one-half of all open top vapor degreasers, and almost all of conveyorized degreasers use distillation as a method for recovering spent solvent.

6.4.2 Regulation by the Proposed Standards

These proposed standards, in addition to RCRA, would prevent the discharge of waste solvent into surface impoundments and basins, and require that waste solvent be deposited in closed containers prior to burial. These additional requirements are necessary to ensure that the waste solvents do not evaporate into the air during their disposal.

6.5 REFERENCES

1. Westlin, P.R., and J.W. Brown. Solvent Drainage and Evaporation From Cold Cleaner Usage. United States Environmental Protection Agency. Research Triangle Park, N.C. January 1978. Table 1.

2. Pelletier, W., and P.R. Westlin. Evaporative Emissions Study on Cold Cleaners. United States Environmental Protection Agency. Research Triangle Park, N.C. May 1977. p.6.

3. Reference 2, Table 2 and 3.

4. Equipment catalogs from Baron-Blakeslee, Chicago, Ill. and Detrex Corp., Detroit, Mich.

5. Richards, D.W., and K.S. Suprenant. Study to Support New Source Performance Standards For Solvent Metal Cleaning Operations - Appendix Reports. Dow Chemical Co. Midland, Mich. Contract No. 68-02-1329. June 30, 1976. Appendix 12.

6. Reference 5. Appendix C3. Table 7.

7. Reference 5. Appendix C10.

8. Data provided by E.I. Dupont de Nemours and Co., Wilmington, Delaware in correspondence from Charles L. Gray, Jr. to Jeffrey Shumaker, of the EPA, dated June 30, 1977.

9. Confidential information provided by Allied Chemical Co., Buffalo Research Laboratory, Buffalo, N.Y., to Gerald R. Goldgraben and Paul C. Clifford of The MITRE Corporation, Metrek Division, on February 14, 1978.

10. Reference 5. Appendix C11.

11. Reference 5. Appendix E4.

12. Reference 5. Appendices E5 and E8.

13. Reference 5. Appendix E7.

14. Data provided by Detrex Corporation, Detroit, Michigan, in a telephone conversation between Richard Clement and James Bick of The MITRE Corporation, Metrek Division, on June 14, 1978.

15. Reference 5. Appendix C7.

16. Data provided by Autosonics Corporation, Norristown, Pennsylvania, in a telephone conversation between Burton Rand and James Bick of The MITRE Corporation, Metrek Division, on July, 1978.

7. ENVIRONMENTAL IMPACT

Volatile organic compound (VOC) emissions from organic solvent cleaners represent about 2.5 percent of total nationwide VOC emissions and 4.1 percent of such emissions from stationary sources*. Degreasing operations rank as the fifth largest stationary source category of VOC emissions.

7.1 AIR POLLUTION IMPACT

Degreasing operations consumed approximately 726,000 metric tons (798,600 short tons) of solvents during 1974. Of this quantity, nearly 706,000 metric tons (775,500 short tons) were released to the environment, primarily as air emissions (Table 7-1).[1]

If use of degreasing processes increase as expected, total uncontrolled emissions from all degreasing operations would exceed 1.5 million metric tons (1.65 million short tons) by 1985 (Table 7-2). Significant reductions in solvent emissions are achievable through the application of emission control equipment and good operating procedures (Table 7-3). Estimated controlled emissions from new source operations (units that come on-line during the period 1980-85) will total 120,000 metric tons (134,200 short tons), as compared to uncontrolled emissions of 332,000 metric tons (366,300 short tons) for the same period. This would represent a 64 percent reduction in new source solvent air emissions (Table 7-4).

Improper maintenance or operation of control equipment, such as saturated

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*For 1974, estimated total VOC emissions were 28 x 10^6 metric tons (30.8 x 10^6 short tons), of which 17 x 10^6 metric tons (18.7 x 10^6 short tons) were from stationary sources.

Table 7-1. CONSUMPTION AND UNCONTROLLED EMISSIONS OF SOLVENTS IN METAL-CLEANING OPERATIONS IN 1974[a]
(thousand metric tons)

Solvent	Consumption [b,c]					Uncontrolled Emissions[d]				
	CC	CCC	OTVD	CVD	TOTAL	CC	CND	OTVD	CVD	TOTAL
Halogenated										
Trichloroethylene	23	2	90	38	153	22	2	90	38	152
1,1,1-Trichloroethane	76	6	57	23	162	73	6	57	23	159
Perchloroethylene	13		29	12	54	12		29	12	53
Methylene Chloride	22	1	5	2	30	21	1	5	2	29
Trichlorotrifluoroethane	9	1	20		30	8	1	20		29
Aliphatic	207	15			222	197	15			212
Aromatic	46				46	44				44
Oxygenated	29				29	28				28
TOTAL	425	25	201	75	726	405	25	201	75	706

[a] Types of solvent metal-cleaning operations are cold cleaning (CC), conveyorized nonboiling degreasing (CND), open top vapor degreasing (OTVD) and conveyorized vapor degreasing (CVD).

[b] Data from Reference 1.

[c] Assumes that solvent usage in conveyorized degreasing is proportional to that in nonconveyorized operations.

[d] Uncontrolled emissions from cold cleaning operations are 20,000 metric tons less than solvent consumption; proper disposal of waste solvent accounts for the difference (Reference 1).

Table 7-2 Uncontrolled Emissions from Degreasers in 1985[a]

Degreasers Type	Number of Units	Emission factors[b] Metric Tons/Unit-Yr.	Emissions Metric Tons
CC	1,780,919	0.487	867,308
OTVD	45,605	11.306	515,610
CD	6,506	28.950	188,349
Total	1,833,030		1,571,267

[a] Does not include emissions due to waste solvent disposal

[b] Emission factors for average degreasing units (Section 8.2).

adsorbent from carbon adsorption systems, maladjusted refrigeration units or excessive ventilation, can lead to increased emissions from individual units. This can be prevented through adequate maintenance programs and proper operator training.

7.2 WATER POLLUTION IMPACT

Waste solvent disposal is the primary source of water pollutants from degreasing operations. Other main sources include water discharge from separators on vapor degreasers and distallation units and steam condensate from regeneration (solvent desorption) of carbon adsorption units.

7.2.1 Waste Solvent Disposal

During 1974, degreasing operations produced approximately 282,000 metric tons (310,200 short tons) of waste solvents (Table 7-3). The disposal methods often provided inadequate destruction and/or containment of the solvents.

TABLE 7-3. APPLICABLE CONTROL EQUIPMENT AND ITS EFFECTIVENESS

	Emissions		Control Equipment		Emissions, 10^3 Metric Tons	
Type of Degreaser	Type	Quantity, %	Type	Demonstrated Efficiency, %	Uncontrolled	Controlled
Cold Cleaner	Bath evaporation	$20^{a,1}$	Cover	$92^{c,2}$	81	d
	Solvent carry-out	$25^{a,1}$	Drain racks or baskets	50^{3}	101	51
	Waste solvent disposal	55^{1}	Holding tank Still Suitable disposal	>85 vol. $\%^{3}$	223	<33
	Ventilation exhaust	45^{b}	Incinerator Carbon adsorber	$60\text{-}90^{4}$	182	18-73
Open Top Vapor Degreaser	Bath evaporation	$31^{a,5}$	Cover	$90^{c,2}$	62	d
			Enclosed design High freeboard	$27^{e,4}$		45
			Condensing coils Refrigerated freeboard device	$30\text{-}40^{4}$		37-43
			Condenser flow switch & thermostat Vapor level control thermostat Sump thermostat Solvent level control Spray safety switch Water separator			
			Lip exhaust with carbon adsorber	70^{4}		19
	Solvent carry-out	$47^{a,5}$	Drain racks Automatic hoist with timed pause		95	
	Waste solvent disposal	22^{1}	Still (built-in or external)	$80\text{-}85^{6}$	44	7-9
	Ventilation exhaust	78^{b}	Incinerator Carbon adsorber	$50\text{-}65^{4}$	157	55-79
Conveyorized Degreaser • All Types	Bath evaporation		Entrance & exit area covers Water separator			
	Solvent carry-out		Drain racks Drying tunnel			
	Waste solvent disposal	15^{1}	Still (built-in or external)		15	
• Cold	Ventilation exhaust	85^{b}	Carbon adsorber	60^{4}	21	8
• Vapor	Bath evaporation		Condensing coils & refrigerated freeboard device Safety switches			
	Ventilation exhaust	85^{b}	Carbon adsorber	$50\text{-}70^{4}$	64	19-32

[a] Relative quantities of emissions during degreasing operations.

[b] Vapors from both bath evaporation and solvent carry-out.

[c] With cover in place.

[d] Depends on percentage of time cover is closed.

[e] By increasing freeboard ratio from 0.5 to 0.75.

Table 7-4 PROJECTED ANNUAL EMISSIONS FROM NEW DEGREASERS, 1979-1985[a,d]

Year	Uncontrolled emissions, 10^3 metric tons								Controlled emissions, 10^3 metric tons								Difference,[b,c] (10^3 metric tons)
	New units				New units: cumulative from 1979[b]				New units				New units: cumulative from 1979[b]				
	CC	OTVD	CD	TOTAL[b]	CC	OTVD	CD	TOTAL	CC	OTVD	CD	TOTAL[b]	CC	OTVD	CD	TOTAL	
1979	26	19	6	52	26	19	6	52	5	11	3	19	5	11	3	19	33
1980	27	20	7	54	53	39	13	105	6	12	3	20	11	23	5	39	67
1981	27	18	6	51	80	57	19	157	6	10	2	18	17	33	8	57	99
1982	28	19	6	54	109	76	26	210	6	11	3	19	22	44	10	76	134
1983	29	20	7	56	138	95	32	266	6	11	3	20	28	55	13	97	169
1984	31	20	7	58	169	116	39	324	6	12	3	21	35	67	16	117	207
1985	32	21	7	60	201	137	46	384	7	12	3	22	41	79	19	139	245

[a] Based on projected numbers of new units (Table 8-6) and emission factors for average degreasing units (Section 8.2):
Cold cleaner: 487 kilograms/year uncontrolled, 100 kilograms/year controlled
Open top vapor degreaser: 11,306 kilograms/year uncontrolled, 6538 kilograms/year controlled
Conveyorized degreaser: 28,950 kilograms/year uncontrolled, 11,580 kilograms/year controlled

[b] Totals may differ due to rounding.

[c] Difference between controlled and uncontrolled emissions from new degreasers placed in service from 1979 on.

[d] Does not include emissions due to waste solvent disposal.

Contamination of natural water systems by waste solvents can occur through direct sewer disposal or as leachate from landfills. The proposed regulations on solid waste disposal practices from organic solvent cleaning facilities are designed to prevent such contamination.

7.2.2 Water Separator Effluent

Small amounts of contaminated water are collected by water separators on vapor degreasers and distillation units. The water is introduced in the process on the parts that are degreased. Generally, effluent from water separators amounts to less than 3.8-7.6 liters (1-2 gallons) per degreaser per day.

The amount of solvent in the discharge depends upon the type of solvent used. The maximum quantity of solvent per liter of water discharge would amount to zero grams of 1,1,1-trichloroethane and trichlorotrifluoroethane, .20 grams of perchloroethylene, 1 gram of trichloroethylene and 20 grams of methylene chloride. These small quantities would have an insignficant effect on wastewater quality.

De-icing of refrigerated control equipment operated below 0°C (32°F), steam stripping of still bottoms on distillation units and other emission control procedures will increase the volume of wastewater discharge. Accurate data on the quantity of discharge from these procedures are not available.

7.2.3 Steam Condensate from Carbon Adsorber Regeneration

7.2.3.1 Solvents in Steam Condensate

The carbon adsorber regeneration process involves passing steam through the carbon bed. Solvents, which were adsorbed by the carbon, are then desorbed by the steam. The adsorbed solvents, except for trichlorotrifluoroethane, are somewhat soluble in water[7] and, therefore, small quantities of solvent remain in the steam condensate portion of the wastewater discharge.

Trichlorotrifluoroethane, perchloroethylene and trichloroethylene along with associated stabilizers*, are amenable to control by carbon adsorption. Due to problems with water-soluble stabilizers, 1,1,1-trichloroethane emissions are not usually controlled by carbon adsorption. Methylene chloride emissions are also not usually controlled by carbon adsorption, due to a corrosion problem associated with steam stripping. The solvent dissolves large quantities of air which can lead to corrosion of the adsorber unit during the steam stripping process.[8]

A large carbon adsorption system for perchloroethylene may use 1890 kilograms (4200 pounds) of steam (about 1900 liters or 500 gallons of water) for each adsorption cycle[9]. The steam is condensed with the solvent, then separated by gravity. Small amounts of solvents and stabilizers remain in the water fraction and are eventually discharged to the wastewater stream. The concentration of solvents and stabilizers in the steam condensate depends on their solubility in water.

7.2.3.1 Solvents in Steam Condensate

Solvent discharge in steam condensate is based on information from carbon adsorber manufacturers and activated carbon producers. According to these industry estimates, around 250 degreasing units were equipped with carbon adsorption systems in 1978.[10] Assuming that 20 percent of new source degreasing units will be equipped with carbon adsorption systems (Table 8-6), it has been estimated that approximately 1962 carbon adsorption systems would come on-line during the period 1980-85. Based on these data, the amount of solvent discharge in steam condensate for the period 1980 to 1985 would be 186 metric tons (204 short tons).

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*Stabilizers, also referred to as inhibitors or additives, are organic compounds that are added in small quantities to chlorinated solvents to inhibit decomposition. The quantity of stabilizers released to the water separator discharge is negligible.

7.2.3.2 Stabilizers in Steam Condensate

Stabilizers are present in steam condensate, from carbon adsorbers, at concentrations that depend on their solubility in water. Compounds which are used as stabilizers for the various chlorinated solvents are known[1,4], however, their exact formulations are trade secrets of the manufacturers. It is, therefore, difficult to estimate the potential discharge of stabilizers dissolved in the steam condensate from regeneration.

The CTG estimates that the maximum potential discharge would result from a solvent combination that contained 5 percent stabilizer* that was 40 percent water soluble[1]. If this condition, along with equal evaporation rates for solvent and stabilizer and maximum adsorption of the chlorinated solvents (see Section 7.2.3.1), are assumed, then 114,100 metric tons (125,500 short tons) of chlorinated solvents (Table 7-1, and 7-3) and 5710 metric tons (6280 short tons) of stabilizers would be adsorbed. The probable maximum discharge (based on Section 7.2.3.1 assumptions) would be 3.7 metric tons (4.1 short tons).

7.3 SOLID WASTE IMPACT

The principal types of solid waste generated from organic solvent cleaners include spent carbon from carbon adsorbtion units, and waste solvent, sump, and still bottoms. It is believed that there would be an insignificant increase in the amount of spent carbon disposed due to this standard of performance. There would not be a incremental increase in the amount of waste solvent disposed, since hazardous waste disposal regulations as required by the Resource Conservation and Recovery Act would control all degreasing operations.

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*1,1,1-trichloroethane requires 5 percent stabilizer, the other solvents require a lower percentage.

7.3.1 Disposal of Spent Carbon

Spent carbon from adsorption systems is easily reactivated and has an estimated life of up to 30 years. Replacement of the carbon, though, is recommended every 10 to 15 years. Assuming that the 1962 new source degreasing operations equipped with carbon adsorption systems contain an average of 635 kilograms (1397 pounds) of carbon which is replaced every ten years, then disposal of spent carbon from adsorbers on new source degreasing operations would amount to 296 metric tons (326 short tons) in 1990 and 267 metric tons (294 short tons) in 1996.

7.3.2 Disposal of Waste Solvent

The waste solvent disposal provisions in this standard of performance would limit the methods of solvent disposal which would be allowed under the Resource Conservation and Recovery Act (RCRA). Organic solvent cleaners which generate less than 100 kg of waste solvent per month would be allowed by RCRA to dispose of their waste in any state approved landfill without using any method of containment. Disposal of solvents by application in landfills could result in the release of volatile organic emissions to the atmosphere by evaporation. Burial of these wastes in closed containers would control these releases.

RCRA also allows for the disposal of hazardous wastes in surface impoundments and basins. High volatility solvents used in degreasing could be emitted as air pollutants if waste solvent was controlled in this manner. Therefore, this standard of performance does not allow for the disposal of waste solvent, sump, and still bottoms in surface impoundments and basins.

Incineration can be used as a disposal method for waste solvents. However, only 25 to 50 domestic incinerators have the gas cleaning equipment necessary for handling chlorinated solvents. This equipment is designed to remove halogenated compounds (primarily hydrochloric acid), particulates and other pollutants.

Based on a survey of 20,000 plants in the metal working industry, it was estimated that 524 metric tons (576 short tons)* of waste solvents were disposed of through incineration during 1974[4]. This amount is only about 0.02 percent of total solvent emissions for that year (Table 7-1). Emissions from the incinerators used for waste solvent disposal may have a regional environmental impact, depending upon their locations.

The best option for controlling waste solvent from organic solvent cleaning facilities is by reclamation, using either distillation or an equivalent method. Where practical, disposal of waste solvent, sump, and still bottoms should be avoided, and alternatives such as recovery and reuse should be employed.

7.4 ENERGY IMPACT

The principal energy consuming emissions control devices for degreasing units are refrigerated freeboard equipment, both portable add-on and built in types. Incinerators are intensive energy consumers, but are used to control only 0.02 percent of total solvent emissions. Lip exhausts also consume large quantities of energy.

Energy consuming emission control devices for degreasing and solvent disposal operations would include (1) refrigerated freeboard devices, (2) carbon adsorption systems, (3) distillation equipment, and (4) incinerators.

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*This is based on the disposal of 364,800 liters (96,000 gallons) of waste solvent with an average density of 1.4 kilogram/liter (12 pounds/gallon).

Operation of this equipment in 1985 would require approximately 0.27 million kWh per day (equivalent to about 440 barrels of oil per day). However, the proposed standards would result in the capture of degreaser emissions equivalent to about 6500 barrels of oil per day. Therefore, these new source performance standards in 1985 would result in a net conservation of energy equivalent to about 6000 barrels of oil per day.

7.4.1 Energy Consuming Equipment

Refrigerated freeboard devices create a cold air blanket over the vapors in an open top vapor degreaser. The refrigeration units use 1/2 to 3 horsepower motors which consume 0.38 to 2.25 kWh (1274 to 7641 BTUs/hr), to drive the compressors.[11,12] Energy consumption for an open top vapor degreaser could increase by an estimated 5 percent with the addition of a typical refrigerated freeboard unit[17].

Portable refrigeration units have cooling capacities of 24,000 to 360,000 BTUs per hour and provide a 10°C (50°F) water supply (based on 35°C (95°F) ambient air temperature). These units, which consume 4.8 to 63 kWh (16,195 to 212,562 BTUs/hr),[12] include circulating pumps that provide coolant to the degreaser's condenser coils.

Carbon adsorption systems require a supply of steam for regeneration and electricity for pumping the cooling water and powering the blower motor. Standard commercially available carbon adsorption systems use blower motors of 3 to 20 horsepower.[13] Design specifications require 1.5 to 6 kilograms of steam per kilogram of solvent capacity of the carbon bed for steam stripping regeneration of the carbon (Table 7-5).[4,9,12,13,14] Energy requirements for carbon regeneration would then range from 3300 to 13,200 BTUs* per kilogram of solvent.**

At present, steam desorption is usually based on a time cycle rather than on the amount of solvent in the carbon bed. Therefore, the quantity of steam used per desorption cycle would be the same regardless of the degree of carbon saturation.

Solvent recovery stills use energy to provide heat for vaporization and cooling for vapor condensation. Heat requirements are met with electricity or steam and condenser cooling can be achieved with pump water or a refrigeration unit. Solvent distillation requires at least 0.1 kWh per kilogram of recovered solvent.[1,4,15,16] Various solvent properties determine the energy required for distillation (Table 7-5).

Incinerators must achieve temperatures of 320 to 490°C (600 to 900°F) for catalytic oxidation of solvent laden gases and temperatures of 760 to 870°C (1400 to 1600°F) for direct thermal combustion. Large quantities of energy are needed to achieve these temperatures. Because of this, incineration is presently used for only a small fraction of total waste solvent disposal. It has been estimated that the energy required for catalytic oxidation of all waste solvent from domestic cold cleaners would equal 1.4×10^{18} BTUs for 1974[4].

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*One kilogram of steam equals 220 BTUs.

**Lip exhaust energy requirements are included with the calculations for carbon adsorption systems.

TABLE 7-5. PROPERTIES RELATED TO ENERGY CONSERVATION[a]

Solvent	Boiling Point,		Specific Heat of Liquid	Heat of Vaporization		Heat Required to Vaporize Liquid from 75°F (24°C)	
	°F	°C	Btu/lb °F, cal/·°C	Btu/lb	cal/g	Btu/gal.	cal/g
Trichlorotrifluoroethane (CFC-113)	117.6	47.6	0.218	63	35	950	63
1,1,1-Trichloroethane	165	74.1	0.258	104	58	1400	93
Perchloroethylene	250	121.1	0.205	90	50	1710	114
Trichloroethylene	188.4	86.9	0.225	103	57	1570	105
Methylene Chloride	103.6	39.8	0.276	142	77	1660	111
High Flash Naphtha[b] (variable composition)	240-320	116-160	0.45	132	73	1390	91
Stoddard Solvent[b] (variable composition)	310-388	154-198	0.52	118	66	1660	111
Isopropyl Alcohol	180	82.3	0.615	285	159	2290	170
Water[c] (Water & Detergents)	212	100	1.00	970	539	9240	615

[a] Reference 18.

[b] Composition varies as it is a mixture that meets a specified boiling range and a limit on unsaturation. Specific heats and latent heats of vaporization are those for typical compounds at the midpoint of the boiling range.

[c] For cleaning purposes, organic surfactants are present in the water at concentration of 1 to 3 weight percent, but they do not significantly alter the physical properties of water that affect distillation and reclamation.

7.4.2 Waste Heat Recovery

Substantial energy savings may be attained when heat recovery systems are used on incinerators. The use of heat recovery systems on incinerators could reduce overall energy usage for catalytic combustion by 40 to 80 percent.[1]

7.4.3 Fuel Switching

Steam is used to regenerate solvent from carbon adsorbers and for distallation. It may also be used as a heat input for vapor degreasing. The steam used in these applications would come from an existing (or newly installed) fossil fuel-fired boiler. The type of fuel (coal, oil or natural gas) used would depend upon the size and type of boiler and the facility in which it is used.

7.4.4 Energy Conservation

It was estimated that with the implementation of this NSPS, use of solvents recovered from carbon adsorption systems would conserve over 6500 barrels of oil per day in the solvent production process during 1985. This energy conservation figure is based on solvent consumption data from the CTG and an estimated average energy requirement of 1.25 barrels of oil per barrel of solvent produced.

7.5 OTHER ENVIRONMENTAL IMPACTS

7.5.1 Noise

Blower noise from carbon adsorbers may constitute an adverse environmental impact. This effect, however, would be localized to the general area in the plant near the adsorber.

Noise level measurements have not been made due to the fact that they appear to be insignificant when compared with the normal noise level in machine shops and other manufacturing areas where carbon adsorbers are located.

While noise does not seem to present a serious environmental problem, it should be considered when the in-plant location of a carbon adsorber is selected. The addition of noise suppression equipment to carbon adsorbers could minimize this problem.

7.5.2 Activated Carbon Requirements for Adsorption Systems

Carbon adsorption systems can use large quantities of activated carbon. An average size adsorber requires 635 kilograms (1390 pounds)[16] of activated carbon and a large adsorber may use up to ten times the amount.

Installation of average size adsorption systems on 1962 new source degreasing operations (see Section 7.2.3.1) would require a total of 1238 metric tons (1362 short tons) of activated carbon for the period 1980-85. This quantity represents less than 1.6 percent of the total domestic activated carbon consumption of 89,000 metric tons (97,900 short tons) for 1977.

7.6 OTHER ENVIRONMENTAL CONCERNS

7.6.1 Environmental Impact of Delayed New Source Performance Standard or no Standard

In response to the National Ambient Air Quality Standard (NAAQS) for photochemical oxidants, state and local governments developed implementation plans and codes to control these pollutants. Restrictions were placed on the quantities of photochemically reactive solvents that could be emitted from various sources in areas were the primary air quality standards could be attained only with the application of emission controls. This includes most industrial regions[4]. Therefore, VOC emissions from many existing degreasing operations are currently regulated.

If this standard of performance is not promulgated or its implementation delayed, new source degreasing units would have to comply with existing state regulations. Existing degreasing operations will not be affected by this standard of performance, unless a unit undergoes significant modifications.

The effect of a delayed standard would be the difference between uncontrolled and controlled solvent emissions from new source degreasing operations during the period of the delay. The estimated annual difference in solvent emissions would be 33,000 metric tons (36,300 short tons) for 1980, increasing up to 211,000 metric tons (232,100 short tons) by 1985 (Table 7-4). If the standard of performance was not promulgated, this difference would total 718,000 metric tons (789,800 short tons) for the period 1980-85.

7.6.2 Summary of Environmental Impact of Proposed Standards

The proposed standards would reduce the emissions of volatile organic compounds and trichloroethylene, perchloroethylene, methylene chloride, 1,1,1-trichloroethane, and trichlorotrifluoroethane from all organic solvent cleaners. With implementation of the new source performance standards, controlled emissions from these facilities would be 120,000 megagrams (about 134,000 tons) in 1985, which constitute a reduction of 64 percent.

The only potentially adverse impact on water quality of the proposed regulation would derive from the solvent dissolved in the steam condensate from regeneration of carbon adsorbers. Only 74 grams (0.16 pounds) of solvent per day is expected to be lost in the waste stream from a typical carbon adsorber; the environmental impact of this small quantity is insignificant.

Promulgation of these proposed standards would also result in a solid waste impact for the disposal of the spent carbon from the carbon adsorbers. Disposal of spent carbon from affected facilities would amount to 243 megagrams (268 tons) nationwide in 1989 and would increase to 271 megagrams (299 tons) in 1995. Thus, the solid waste impact would also be minimal.

7.7 REFERENCES

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8. ECONOMIC IMPACT

8.1 INDUSTRY ECONOMIC PROFILE

8.1.1 Introduction

Organic solvent cleaners are used in the production, installation, and maintenance of virtually all metal based commodities. Typically it represents only a small part of a given firm's operations, measured in terms of its share of total costs of production (see Table 8-4). Any changes in organic solvent cleaning costs are therefore likely to have only a small impact on the behavior of firms and industries. Nevertheless, individually small effects may be significant when aggregated and it is important to identify and quantify them in order to assess the impact of a New Source Performance Standard (NSPS) for organic solvent cleaners.

The impact of New Source Performance Standards is not just limited to firms utilizing organic solvent cleaners. Changes in firms' decisions on rates of replacement of existing degreasing equipment and rates of acquisition of additional machinery are likely to result from NSPS regulations. Further, selections of types of solvent and volume of solvents used in degreasing processes will change as a result of new environmental regulations. As a consequence, producers of degreasing equipment and producers of solvents will be affected by this NSPS.

The regulations will also impinge upon market conditions facing a third group, the household sector. Changes in firms' costs of production may well be passed on to consumers, in part or in full, in the form of higher or lower prices. Where organic solvent degreasing firms make final goods or services, as is the case with auto repairs, the price impact will be direct. When firms make intermediate goods such as sheet metal the impact will be indirect, affecting final commodity costs of production and prices via the prices of inputs.

Two of the above groups are directly involved with organic degreasing: (1) producers of organic degreasing equipment and solvents and (2) firms utilizing organic solvent cleaners. Therefore, the industry profile focuses upon these two sectors.

8.1.2 Industry Characteristics

8.1.2.1 Suppliers

Degreasing Equipment Manufacturers. Degreasing equipment used in the U.S.A. ranges from old drums filled with kerosene to large conveyorized degreasers costing up to $250,000. Three types of degreasers have been identified: cold cleaners, open top vapor degreasers and conveyorized degreasers. Conveyorized degreasers are divided into two sub-categories: (1) boiling conveyorized degreasers and (2) non-boiling conveyorized degreasers. Cold cleaners, using non-boiling solvent are produced by the following companies: Safety-Kleen, Kleer-flo, Graymills, D. C. Cooper, Build-All, Kamas, and R&D Manufacturing. Together they produce an estimated 118,700 cold cleaners annually.

Two types of broad marketing strategy have been adopted by cold cleaner producers. Safety Kleen Corporation rents its units to clients and performs all maintenance work itself, providing and recycling solvent used in them. In 1978, it had 185,000 units in operation (mainly in automotive repair shops and automobile dealerships). Other companies simply sell their product to individual customers, who are then responsible for maintenance and the changing and disposal of solvent.

Most vapor degreasers, both open top and conveyorized, are produced by Detrex Chemical Industries and Baron-Blakeslee Incorporated. These two corporations both estimate that they have a joint market share of 80-90%.[1,2] Other manufacturers include Phillips Manufacturing, Lenape, AutoSonics Incorporated, Delta Incorporated, Crest Ultrasonics, and Branson Cleaning Equipment. Industry estimates place annual sales of open top vapor degreasers and conveyorized degreasers at 3,700 and 300, respectively.*

Other companies produce ancillary emissions control equipment, such as carbon adsorbers, refrigerated freeboard chillers, and water barriers. VIC Manufacturing estimates that it has sold approximately 1,000 carbon adsorbers "over the past few years."[3] Detrex expects sales of such ancillary equipment to increase in the future because of current and prospective OSHA and EPA regulations. The company is now developing a line of accessories including spring loaded covers, carbon adsorbers and refrigerated chillers.[1]

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*See Appendix F for discussion of these estimates

Solvent Manufacturers. The organic solvents used in degreasing may be divided into two broad categories: (1) halogenated solvents, used in vapor degreasers and (2) non-halogenated solvents, including petroleum solvents, alcohols and ketones, used in cold cleaning. Major producers of halogenated solvents are identified, by type of solvent, in Table 8-1. They include Dow, Dupont, Ethyl, PPG Industries, Diamond Shamrock, Vulcan, Hooker and Stauffer. Producers of petroleum solvents, ketones and acetones include Exxon Chemical, Shell Chemical & Union Carbide.[4]

The market for organic solvents is discussed in some detail in section 8.1.3. However, it is worth noting here that total sales of solvents used in degreasing accounted for less than one percent of the almost twenty-eight billion dollars worth of synthetic organic chemicals produced in 1976 and only an estimated 3,000 jobs were associated with the production of such solvents.* Any NSPS related to organic solvent cleaning is therefore likely to have only a small impact on the synthetic organic chemicals industry.

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*Surprenant et al[3] provided estimates of sales of solvents in 1976; data on value of output of synthetic organic chemicals and employment were taken from The Annual Survey of Manufacturers, 1976.[5].

Table 8-1. Producers of Halogenated Solvents.

Type of Solvent	Producers
Trichloroethylene	PPG Industries, Dow, Diamond Shamrock, Hooker, Ethyl
Perchloroethylene	Dow, PPG Industries, Vulcan Materials, Diamond Shamrock, DuPont, Stauffer, Ethyl, Hooker
1,1,1-Trichloroethane	Dow, PPG Industries, Vulcan Materials, Ethyl
Methylene Chloride	Dow, Vulcan, Diamond Shamrock, Stauffer, Allied Chemical, DuPont
Trichlorotrifluoroethane	DuPont, Allied Chemical

Source: Reference 4.

8.1.2.2 Users of Degreasers

a) User Industries

Organic solvent cleaners are used in a number of manufacturing sectors and several service sectors (maintenance and repair activities) within the economy. Manufacturing industries which use degreasers are included within the following two-digit SIC code sectors: 25 (Metal Furniture), 33 (Primary Metals), 34 (Fabricated Products), 35 (Non-Electric Machinery), 36 (Electric Equipment), 37 (Transportation Equipment), 38 (Instruments and Clocks) and 39 (Miscellaneous Industry). As detailed in Appendix F, the study conducted by Eureka Laboratories in California (Leung et. al.,[6]) is used to identify the specific three-digit SIC manufacturing industries in which organic solvent degreasing occurs. These sectors are identified in Table 8-2. The service sectors which do organic solvent cleaning are: 401 (Railroads-maintenance), 458 (Air Transport-maintenance) and 753 (Auto Repair).

For each user industry, Table 8-2 presents estimates of the value of output, number of employees, and capital stock for 1976, together with an estimate of the return on capital. Note that there is considerable variation among industries on the basis of any one of those factors. The smallest three-digit industries which use degreasing are Miscellaneous Furniture and Fixtures (259), with output of $1,044 million and employment of 26,100 for 1976, and Miscellaneous Primary Metal Products (339), with output of $1,236 million and employment of 24,600 in 1976. Miscellaneous Furniture and Fixtures (259) also had

Table 8-2 Industries Using Degreasers by SIC Code - 1976

SIC	Industry	1976 Value of Output ($\$10^6$)	Number of Employees (10^3)	Capital Stock ($\$10^6$)	Profit Rate (%)
25	Metal Furniture	1,952	50.9	435.9	3.35
254	Partitions and Fixtures	1,044	26.1	165.5	3.35
259	Misc. Furniture and Fixtures				
33	Primary Metals				
332	Iron and Steel Foundries	9,787	216.4	5,014.9	3.64
335	Nonferrous Rolling and Drawing	18,753	171.3	7,049.0	3.64
336	Nonferrous Foundries	3,389	84.7	1,131.1	3.64
339	Misc. Primary Metal Products	1,236	24.6	559.4	3.64
34	Fabricated Products				
342	Cutlery, Hand Tools, and Hardware	7,392	158.4	2,226.0	8.84
343	Plumbing and Heating (except Electric)	2,608	50.6	658.3	8.84
344	Fabricated Structural Metal Products	21,584	401.4	5,125.3	8.84
345	Screw Machine Products, Bolts, etc.	4,396	99.6	1,747.0	8.84
346	Metal Gorgings and Stampings	15,250	265.4	5,655.5	8.84
347	Metal Services	2,877	89.8	995.7	8.84
348	Ordinance and Accessories	2,804	74.7	731.7	8.84
349	Misc. Fabricated Metal Products	12,612	259.2	3,742.6	8.84
35	Non-Electric Machinery				
351	Engines and Turbines	9,009	124.6	3,305.4	8.41
352	Farm and Garden Machinery	10,534	146.0	2,185.8	8.41
353	Construction and Related Machinery	19,741	311.5	5,750.2	8.41
354	Metalworking Machinery	11,278	289.5	4,382.8	8.41
355	Special Industrial Machinery	9,454	196.2	2,686.7	8.41
356	General Industrial Machinery	14,196	280.7	4,845.0	8.41
357	Office and Computing Machines	13,723	229.4	3,340.1	8.41
358	Refrigeration and Service Machinery	10,660	172.9	2,548.9	8.41
359	Misc. Machinery, except Electrical	6,930	209.0	2,698.3	8.41

Table 8-2 (continued)

SIC	Industry	1976 Value of Output ($\$10^6$)	Number of Employees (10^3)	Capital Stock ($\$10^6$)	Profit Rate (%)
36	Electric Equipment				
361	Electric Distributing Equipment	4,688	104.1	1,274.3	4.50
362	Electrical Industrial Apparatus	8,453	194.7	2,746.0	4.50
364	Electric Lighting and Wiring Equipment	7,342	159.2	2,105.0	4.50
366	Communication Equipment	19,138	421.5	4,806.6	4.50
367	Electronic Components and Accessories	12,433	323.0	5,227.6	4.50
369	Misc. Electrical Equip. and Supplies	6,829	129.6	1,884.2	4.50
37	Transportation Equipment				
371	Motor Vehicles and Equipment	95,381	797.1	17,496.3	3.62
372	Aircraft and Parts	23,463	408.0	5,777.8	3.62
376	Guided Missiles, Space Vehicles, Parts	7,142	141.7	1,778.6	3.62
379	Misc. Transportation Equipment	3,117	49.7	396.1	3.62
38	Instruments and Clocks				
381	Engineering and Scientific Instruments	1,847	43.5	406.0	10.13
382	Measuring and Controlling Devices	6,180	168.9	1,574.3	10.13
39	Miscellaneous Industry	16,286	410.0	3,805.3	6.44
401	Railroads - Maintenance	18,536	496.5	26,925.0	1.20
458	Air Transport - Maintenance	3,701	N.A.	N.A.	N.A.
753	Auto Repair	13,269	1763.0	10,316.0	3.04

Source: Reference 5, 56 and 57.

the smallest capital stock by far ($165.5 million), and no manufacturing industry earned a lower rate of profit (3.35 percent). At the other end of the spectrum, the Motor Vehicle and Equipment sector (371) produced $95,381 million of output in 1976. The value of output in sector 371 was more than four times the value of output in the next largest industry, 372-Aircraft and Parts ($23,463); the number of employees in sector 371 (797,100) was almost twice as large as the number in the next largest manufacturing employer, 366-Communication Equipment (421,500).

Industry 371 also had the largest manufacturing capital stock ($17,496.3 million). Note that capital stock figures vary substantially even when the value of output is considered. While industry 366 (Communication Equipment) produced output worth $19,138 million in 1976, with a capital stock of $4,806.6 million, Industry 335 (Nonferrous Rolling and Drawing) produced output worth $18,763 million, but with capital stock worth $7,049 million. Rates of profit vary considerablly, also. The service industries earned the lowest returns: 1.2 percent in railroads and 3.04 percent in auto repair. The highest return, 10.13 percent, was earned in Industry 38 (Instruments and Clocks); the lowest manufacturing return, 3.35 percent, is earned in Industry 25 (Metal Furniture).

As noted, the industries which use organic solvent cleaners vary substantially. Two additional points must be made about this variation. First, differences occur not only between two-digit industries, but also between three-digit industries within any given two-digit sector. Disaggregation to the three-digit level therefore adds substantial accuracy to the analysis. Second, variations in ouput, employment and capital stock are highlighted largely in order to produce a more complete picture of the industries which do degreasing. There is no simple, direct connection between the magnitude of any of these variables and the amount of degreasing done in any particular industry. The number of degreasers of different types which are located in that sector is a better indication of the importance of organic solvent cleaning in the industry.

b) Estimated Numbers of Degreasers by SIC Code Industry

Table 8-3 presents estimated numbers of degreasers for 1976 by three-digit SIC Code industry. Cold cleaners, open top vapor degreasers, and conveyorized degreasers are treated separately. The estimated numbers of each type of degreaser per million dollars of industry output are included as well. Note that in addition to the degreasers allocated to specific manufacturing and service industries for the production of output, there are 345,773 cold cleaners in what is called "general industry usage." These degreasers are used throughout industry for internal maintenance, and cannot be allocated to specific three-digit sectors. (For information regarding estimation procedures, see Appendix F.)

An estimated 1,268,000 cold cleaners were in use in 1976. Of these, 416,879 were used in producing manufactured products, 505,348

Table 8-3. Estimated Numbers of Degreasers by SIC Code, 1976.

SIC	Industry	Value of 1976 output ($10^6)	Estimated no. of degreasers, 1976			Estimated no. of degreasers per $ million of output		
			Cold Cleaners	Open top vapor	Convey-orized	Cold cleaners	Open top vapor	Convey-orized
25	Metal Furniture							
254	Partitions and Fixtures	1,952	6,156	351	117	3.153	0.180	0.060
259	Misc. Furniture and Fixtures	1,044	3,265	109	36	3.127	0.104	0.034
33	Primary Metals							
332	Iron and Steel Foundries	9,787	1,992	137	34	0.204	0.014	0.003
335	Nonferrous Rolling and Drawing	18,753	2,246	277	70	0.120	0.015	0.004
336	Nonferrous Foundries	3,389	4,058	105	25	1.197	0.031	0.007
339	Misc. Primary Metal Products	1,236	9,715	1,254	313	7.863	1.015	0.253
34	Fabricated Products							
342	Cutlery, Hand Tools, and Hardware	7,392	11,891	1,152	280	1.608	0.156	0.038
343	Plumbing and Heating (except Electric)	2,608	2,772	205	49	1.063	0.079	0.019
344	Fabricated Structural Metal Products	21,584	25,131	771	187	1.164	0.036	0.009
345	Screw Machine Products, Bolts, etc.	4,396	5,409	160	39	1.230	0.036	0.009
346	Metal Gorgings and Stampings	15,250	5,892	205	50	0.386	0.013	0.003
347	Metal Services	2,877	19,157	1,124	273	6.658	0.391	0.095
348	Ordnance and Accessories	2,804	132	5	1	0.047	0.002	0.000
349	Misc. Fabricated Metal Products	12,612	16,024	864	209	1.270	0.069	0.017
35	Non-Electric Machinery							
351	Engines and Turbines	9,009	792	33	6	0.088	0.004	0.001
352	Farm and Garden Machinery	10,534	8,238	304	65	0.782	0.029	0.006
353	Construction and Related Machinery	19,741	11,089	451	96	0.562	0.023	0.005
354	Metalworking Machinery	11,278	38,152	569	122	3.383	0.050	0.011
355	Special Industrial Machinery	9,454	10,467	41	9	1.107	0.004	0.001
356	General Industrial Machinery	14,196	30,734	1,876	402	2.165	0.132	0.028
357	Office and Computing Machines	13,723	4,589	220	47	0.334	0.016	0.003
358	Refrigeration and Service Machinery	10,660	6,085	169	35	0.571	0.016	0.003
359	Misc. Machinery, except Electrical	6,930	79,547	1,085	232	11.478	0.157	0.033

Table 8-3 (continued)

SIC	Industry	Value of 1976 output ($10⁶)	Estimated no. of degreasers, 1976			Estimated no. of degreasers per $ million of output		
			Cold Cleaners	Open top vapor	Convey-orized	Cold cleaners	Open top vapor	Convey-orized
36	Electric Equipment							
361	Electric Distributing Equipment	4,688	3,945	871	115	0.842	0.186	0.025
362	Electrical Industrial Apparatus	8,453	4,138	279	36	0.490	0.033	0.004
364	Electric Lighting and Wiring Equip.	7,342	10,935	2,465	324	1.489	0.336	0.044
366	Communication Equipment	19,138	11,339	2,539	333	0.592	0.133	0.017
367	Electronic Components and Accessories	12,433	10,196	1,362	178	0.820	0.110	0.014
369	Misc. Electrical Equip. and Supplies	6,829	4,989	71	10	0.731	0.010	0.001
37	Transportation Equipment							
371	Motor Vehicles and Equipment	95,381	10,944	630	89	0.115	0.007	0.001
372	Aircraft and Parts	23,463	11,967	2,779	393	0.510	0.118	0.017
376	Guided Missiles, Space Vehicles, Parts	7,142	716	178	25	0.100	0.025	0.004
379	Misc. Transportation Equipment	3,117	4,358	0	0	1.398	0	0
38	Instruments and Clocks							
381	Engineering and Scientific Instruments	1,847	6,086	550	32	3.295	0.298	0.017
382	Measuring and Controlling Devices	6,180	17,797	3,194	187	2.880	0.517	0.030
39	Miscellaneous Industry	16,286	15,936	614	73	0.978	0.038	0.004
	Total Manufacturing	423,508	416,879	26,999	4,492	0.984	0.064	0.011
401	Railroads - Maintenance	18,536	1,161	61	0	0.063	0.003	0
458	Air Transport - Maintenance	3,701	36,160	3,279	0	9.770	0.886	0
753	Auto Repair	13,269	468,027	0	0	35.272	0	0
	Total Services	-	505,348	3,340	0	-	-	-
	General Industry Usage	-	345,773	0	0	-	-	-
	TOTAL	-	1,268,000	30,339	4,492	-	-	-

Source: Appendix F, and Reference 5.

were located in service industries, and 345,773 were in general industry usage. Among service industries, the auto repair sector (753) had by far the largest number of cold cleaners (468,027 of 505,348, or 93 percent). This corresponds to over thirty-five cold cleaners per million dollars of auto repair activity, the largest number per million dollars of output in any sector, manufacturing or service.

In 1976, four manufacturing industries were using more than 20,000 cold cleaners: 359-Miscellaneous Machinery, except Electrical (79,547); 354-Metalworking Machinery (38,152); 357-Office and Computing Machines (30,734); and 344-Fabricated Structural Metal Products (25,131). Twelve manufacturing industries used between ten and twenty thousand cold cleaners, while seventeen used from one to ten thousand cold cleaners. The remaining three industries used less than one thousand units each.

On a per million dollars of output basis, the greatest concentration of manufacturing cold cleaners was in the same industry which had the largest number of cold cleaners, 359-Miscellaneous Machinery, except Electrical (11.5 per million dollars). Two other manufacturing industries had more than five cold cleaners per million dollars of output: Industry 339-Miscellaneous Primary Metal Products (7.9) and Industry 347-Metal Services (6.7). Note that Industry 339 had only an intermediate absolute number of cold cleaners (9,715), but a high number per million dollars of output (7.9). Both Industry 254-Partitions and Fixtures and Industry 259-Miscellaneous Furniture and Fixtures had 3.2 cold cleaners per million dollars of output. Industries 381-Engineering and Scientific Instruments and 382-Measuring and Controlling Devices had 3.3 and 2.9 cold cleaners per million dollars of output, respectively. Industry 354-Metalworking Machinery is the only other sector with more than three cold cleaners per million dollars of production. Nine industries had between one and two cold cleaners per million dollars of output, while the remaining eighteen had less than one.

In 1976, there were 30,399 open top vapor degreasers in operation. Of these, 26,999 or 89 percent were in manufacturing. Virtually all of the eleven percent in services were used in air transport maintenance. Only four industries had more than two thousand open top vapor degreasers: 382-Measuring and Controlling Devices (3,194); 372-Aircraft and Parts (2,779); 366-Communication Equipment (2,539); and 364-Electric Lighting and Wiring Equipment (2,465). Note that these industries had moderate numbers of cold cleaners, indicating that a large number of one type of degreaser does not necessarily mean either a large or a small number of another type. Six industries had between one and two thousand open top vapor degreasers, while eight had between five hundred and one thousand, nine had between two hundred and five hundred, and nine had less than 200. The remaining four manufacturing industries had less than one hundred open top vapor degreasers.

Only four manufacturing industries had more than three-tenths of an open top vapor degreaser per million dollars of output: 339-Miscellaneous Primary Metal Products (1.02); 382-Measuring and Controlling Devices (0.52); 347-Metal Services (0.39); and 364-Electric Lighting and Wiring Equipment (0.34). With the exception of Industry 364, these industries also had among the highest numbers of cold cleaners per million dollars of production. Ten industries had between one-tenth and three-tenths of an open top vapor degreaser per million dollars of output while twenty-two had less than one-tenth.

In 1976, there were 4,492 closed conveyorized degreasers in use, all of which were located in manufacturing industries. Five industries had more than three hundred such degreasers: 356-General Industrial Machinery (402); 372-Aircraft and Parts (393); 366-Communication Equipment (333); 364-Electric Lighting and Wiring Equipment (324); and 339-Miscellaneous Primary Metal Products (131). These industries also had reasonably large numbers of open top vapor degreasers. Ten industries had between one hundred and three hundred conveyorized degreasers while twenty-one industries had less than 100. Note that Industries 348 and 351 have very small numbers of all types of degreasers, while Industries 356 and 372 have reasonably large numbers of all types.

Conveyorized degreasers per million dollars of output range from zero to 0.253 (339-Miscellaneous Primary Metal Products). Aside from Industry 339, all estimates are less than one-tenth of a degreaser.

Industries 254-Partitions and Fixtures (0.060) and 347-Metal Services (0.095) had the next highest estimates. Fourteen industries had between .01 and .05 conveyorized degreasers per million dollars of output while nineteen industries had less than .01.

c) Estimated Costs of Degreasing Operations

The most significant indicator of the importance of degreasing activities within any particular industry is the share of total industry costs (measured by value of industry shipments) accounted for by organic solvent cleaners. Total industry degreasing costs and cost shares by type of degreasing activity are presented in Table 8-4. These costs were estimated by combining cost data for typical uncontrolled degreasing operations in each industry (presented in Appendix F) with the data on numbers of degreasers in each industry presented in Table 8-3. According to RTI's estimates, American industry spent approximately $1,948,700,000. on organic solvent degreasing in 1976. This represents less than four-tenths of one percent of the total value of industry output. Cold cleaning accounted for about $1,377,000,000., or a little more than 70 percent of total industrial degreasing costs. Open top vapor degreasing accounted for another 21 percent, and conveyorized degreasing the remaining 9 percent of total degreasing costs. In the thirty-nine industries identified as major users of degreasing equipment, total degreasing costs exceeded one percent of value of shipments in only ten industries and two percent in only three.

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Table 8-4. Degreasing Cost Shares by Degreasing Process for SIC Code Industries

SIC code (Short Title)	Value of Shipments	Cold Cleaning Costs		Open Top Vapor Degreasing Costs		Conveyorized Decreasing Cost		Total Degreasing Costs	
		Million $	% of value of shipments	Million $	% of value of shipments	Million $	% of value of shipments	Million $	% of value of shipments
254 Partitions and Fixtures	1952.3	19.484	.998	4.8122	.246	3.786	.194	28.081	1.438
259 Misc. Furniture and Fixtures	1044.1	9.051	.867	1.5337	.147	1.134	.109	11.718	1.122
332 Iron and Steel Foundries	9787.0	7.335	.075	2.3017	.024	1.195	.012	10.831	.111
335 Nonferrous Rolling and Drawing	18753.3	8.095	.043	4.5891	.024	2.438	.013	15.122	.081
336 Nonferrous Foundries	3389.4	12.957	.382	1.6102	.048	0.830	.024	15.397	.454
339 Misc. Primary Metal Products	1235.6	37.238	3.014	21.6365	1.751	11.188	.905	70.062	5.670
342 Cutlery, Hand Tools, and Hardware	7392.5	37.968	.514	17.6659	.239	9.292	.126	64.926	.878
343 Plumbing and Heating (except Electric)	2608.0	8.333	.320	3.0285	.116	1.590	.061	12.951	.497
344 Fabricated Structural Metal Products	21583.9	81.827	.379	11.9675	.055	6.253	.029	100.047	.464
345 Screw Machine Products, Bolts, etc.	4396.0	17.325	.394	2.4586	.056	1.296	.029	21.080	.480
346 Metal Gorgings and Stampings	15249.7	21.512	.141	3.4249	.022	1.751	.011	26.688	.175
347 Metal Services	2877.1	53.295	1.852	15.8506	.551	8.612	.299	77.757	2.703
348 Ordnance and Accessories	2804.3	0.384	.014	0.0725	.003	0.032	.001	0.489	.017
349 Misc. Fabricated Metal Products	12612.1	51.918	.412	13.3704	.106	6.975	.055	72.264	.573
351 Engines and Turbines	9009.1	3.113	.035	0.5791	.006	0.217	.002	3.909	.043
352 Farm and Garden Machinery	10533.7	29.986	.285	5.0695	.048	2.273	.022	37.329	.354
353 Construction and Related Machinery	19740.8	40.076	.203	7.4857	.038	3.348	.017	50.909	.258
354 Metalworking Machinery	11278.2	136.088	1.207	9.3646	.083	4.232	.038	149.684	1.327
355 Special Industrial Machinery	9453.5	34.185	.362	0.6377	.007	0.301	.003	35.124	.372
356 General Industrial Machinery	14196.5	106.278	.749	30.2599	.213	13.768	.097	150.306	1.059
357 Office and Computing Machines	13722.8	14.822	.108	3.3977	.025	1.567	.011	19.787	.144
358 Refrigeration and Service Machinery	10660.2	19.429	.182	2.5916	.024	1.162	.011	23.183	.217
359 Misc. Machinery, except Electrical	6930.5	268.471	3.874	17.2309	.249	7.868	.114	293.570	4.236
361 Electric Distributing Equipment	4688.0	12.352	.263	13.1939	.281	3.788	.008	29.334	.626
362 Electrical Industrial Apparatus	8452.9	12.675	.150	4.1697	.049	1.176	.014	18.020	.213
364 Electric Lighting and Wiring Equip.	7342.0	32.925	.448	36.4549	.497	10.517	.143	79.897	1.088
366 Communication Equipment	19138.0	38.564	.202	40.5199	.212	11.328	.059	90.412	.472
367 Electronic Components and Accessories	12432.7	26.673	.215	18.5069	.149	5.497	.044	50.676	.408
369 Misc. Electrical Equip. and Supplies	6829.1	17.047	.250	1.1364	.017	0.341	.005	18.525	.271
371 Motor Vehicles and Equipment	95381.4	45.647	.048	11.5088	.012	3.302	.003	60.458	.063
372 Aircraft and Parts	23463.0	45.870	.196	47.9489	.204	14.048	.060	107.867	.498
376 Guided Missiles, Space Vehicles, Parts	7141.6	1.992	.028	2.5102	.035	0.789	.011	5.291	.074
379 Misc. Transportation Equipment	3116.8	12.124	.389	0.0000	.000	0.000	.000	12.124	.389
381 Engineering and Scientific Instruments	1846.8	19.147	1.037	8.3567	.452	1.056	.057	28.559	1.546
382 Measuring and Controlling Devices	6180.2	52.288	.846	46.5366	.753	6.015	.097	104.840	1.696
390 Miscellaneous Industry	2691.3	40.860	1.518	8.2565	.307	2.239	.083	51.355	1.908
401 Railroads - Maintenance	18536.0	4.710	.025	1.093	.006	0.0	.000	5.803	.031
458 Air Transport - Maintenance	3701.0	138.782	.749	56.625	.305	0.0	.000	195.407	.054
753 Auto Repair	13269.0	1796.287	13.537	0.0	.000	0.0	.000	1796.287	13.538

Source: Tables 8-2 and 8-6.

The manufacturing industry most significantly involved in organic solvent degreasing is SIC 339, Miscellaneous Primary Metal Products. This classification includes metal heat treating and the manufacture of products such as nails and spikes which must be clean when shipped. Degreasing represents more than 5.6 percent of the industry's value of shipments, or about 70 million dollars. More than half of this amount is attributed to cold cleaning, but significant open top and conveyorized degreasing activity takes place as well. SIC 359, Miscellaneous Non-Electrical Machinery, had degreasing costs of 293 million dollars in 1976, accounting for 4.2 percent of industry value of output. Almost all of this amount was for cold cleaning, the process requiring the least expensive control equipment. In SIC 347, metal services, degreasing represented more than 2.7 percent of total costs, of which two thirds consisted of expenditures on cold cleaning. In addition, three transport and service industries, 753-auto repairs, 458-air transport maintenance and 401-railroad maintenance accounted for 1,997 million dollars of degreasing activity in 1976. About 90 percent of this total, an estimated 1,796 million dollars, was spent on degreasing in auto and truck maintenance and repair. This amount is more than 13.5 percent of the industry's total receipts. This estimate is based on the assumption that a quarter of one mechanic's time is spent running each degreaser. Degreasing may not ordinarily require this much labor. Consequently, the estimate should be regarded as a maximum figure.

It is important to note that degreasing activities represent a significant part of total operations in some industries where profit rates are low. This is most apparent in the case of SIC 753 (auto repair). As noted above, degreasing costs represent an estimated 13.5% of total costs in that industry while the rate of profit is only 3.04%. A similarly situated industry is SIC 339 (Miscellaneous Primary Metal Products) where degreasing activities represent 5.7% of total costs and the rate of profit is 3.64%. Of the remaining industries in which degreasing costs represent more than 1% of total costs, only two (SIC's 254 and 259) have profit rates which are lower than 4% (3.5% in both cases). This suggests that typical firms in those industries may have some difficulty in financing the capital investments made necessary by the controls. However, for the remaining industries that should not be the case. In this context, it is worth noting that in the industry experiencing the lowest profit rate (1.2%) in 1976 (401-railroad maintenance), estimated degreasing costs represent less than 0.031% of total costs. Thus, it seems unlikely that the capital cost of NSPS control equipment would be burdensome for that industry.

d) Estimate Numbers of Degreasers by Geographic Location

Table 8-5 presents estimated numbers of degreasers for 1976 by geographic location. Cold cleaners, open top vapor degreasers and conveyorized degreasers are considered separately. Estimated manufacturing totals and overall totals are both given. Tables F1-3,

Table 8-5 Estimated Numbers of Degreasers for 1976 by Geographic Location

Degreaser Type	North East	Mid Atlantic	East North-Central	West North-Central	South Atlantic	East South-Central	West South-Central	Mountain	Pacific	TOTAL
Manufacturing										
Cold Cleaners	34,629	79,851	147,308	30,152	28,942	17,592	22,974	7,454	50,167	419,069
Open Top Vapor Degreasers	2,658	5,516	8,148	1,758	1,860	1,058	1,444	548	4,047	27,037
Closed Conveyorized Degreasers	413	890	1,477	293	308	190	249	77	602	4,499
TOTAL										
Cold Cleaners	76,156	197,503	335,413	111,066	152,824	74,939	122,985	45,967	149,987	1,268,001
Open Top Vapor Degreasers	2,778	5,744	8,646	2,241	2,310	1,315	1,973	863	4,446	30,377
Closed Conveyorized Degreasers	413	890	1,477	293	308	190	249	77	602	4,499

Source: Appendix F

F1-4 and F1-5 in Appendix F show the estimated numbers of cold cleaners, open top vapor degreasers, and conveyorized degreasers, respectively, by location and three-digit industry. The geographic distribution of degreasers within each industry is based on the geographic shares of the national value of shipments for that industry for 1972. (For more information on the estimation procedure, see Appendix F.)

The highest concentration of degreasers used in manufacturing was in the East North Central section of the United States. This area had 147,308 cold cleaners, 8,148 open top vapor degreasers and 1,477 conveyorized degreasers in manufacturing, representing 35, 30 and 33 percent, respectively, of the total numbers of manufacturing degreasers. Comparable numbers for the Middle Atlantic states are 79,851 cold cleaners (19 percent), 5,516 open top vapor degreasers (20 percent), and 890 conveyorized degreasers (20 percent). The Mountain states had the fewest manufacturing degreasers, with 7,454 cold cleaners (2 percent), 548 open top vapor systems (2 percent), and 77 conveyorized degreasers (2 percent).

Total numbers of degreasers (including service and general usage degreasers, as well as manufacturing degreasers) were distributed similarly, but more evenly. In particular, the inclusion of service and general usage degreasers reduces the concentration of cold cleaners and open top vapor systems in the East North Central and Middle Atlantic states. These two areas accounted for 54 percent of all manufacturing cold cleaners and 51 percent of all manufacturing open top vapor degreasers. Comparable percentages for total degreasers are 42 percent and 47 percent. The shares of cold cleaners and open top vapor degreasers found in the southern and the western parts of the U.S. increase when service and general usage categories are included.

e) Projections of Organic Solvent Degreasers for 1980 and 1985

Projected numbers of degreasers for 1980 and 1985 are based on projected values of shipments for the appropriate three-digit industries. These projected values are developed using the Bureau of Labor Statistics' projected growth rates for 1976 to 1980 and for 1980 to 1985.[7,8] The number of each type of degreaser in each industry is assumed to increase by the same proportion as output in that industry. Note that this amounts to an assumption of fixed proportions in production in each of the three-digit industries, or, alternatively expressed, to an assumption of fixed input-output coefficients. These fixed coefficients are used to generate projections of both output and numbers of degreasers. These projections are virtually unaffected by the introduction of New Source Performance Standards and therefore represent both the pre-standard and post-standard estimates of degreaser utilitzation in 1980 and 1985.* Table 8.6 presents projected values of shipments and projected numbers of degreasers for 1980 and 1985 by three-digit SIC

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*See section 8.4.4 for discussion of the impact of NSPS's on the numbers of each type of degreaser required by each industry.

Table 8-6. PROJECTED NUMBERS OF DEGREASERS FOR 1980 AND 1985 BY SIC CODE.

SIC	Industry	Value of Shipment (\$$10^6$, 1976)			No. of Cold Cleaners			No. of Open Top Vapor Degreasers			No. of Conveyorized Degreasers			% Growth Rates	
		1976	1980	1965	1976	1980	1985	1976	1980	1985	1976	1980	1985	1976-1980	1980-1985
25	Metal Furniture														
254	Partitions and Fixtures	1,952	2,319	2,689	6,156	7,313	8,478	351	417	483	117	139	161	4.4	3.0
259	Misc. Furniture and Fixtures	1,044	1,240	1,438	3,265	3,879	4,496	109	129	150	36	43	50	4.4	3.0
33	Primary Metals														
332	Iron and Steel Foundries	9,767	10,064	11,003	1,992	2,048	2,239	137	141	154	34	35	38	0.7	1.8
335	Nonferrous Rolling and Drawing	18,753	20,700	25,064	2,246	2,479	3,002	277	206	370	70	77	94	2.5	3.9
336	Nonferrous Foundries	3,389	3,693	4,067	4,058	4,410	4,869	105	114	126	25	27	30	2.1	2.3
339	Misc. Primary Metal Products	1,236	1,423	1,579	9,715	11,191	12,417	1,254	1,445	1,603	313	361	400	3.6	2.1
34	Fabricated Products														
342	Cutlery, Hand Tools, and Hardware	7,392	8,403	9,882	11,891	13,645	15,895	1,152	1,322	1,540	260	321	374	3.5	3.1
343	Plumbing and Heating (except Electric)	2,608	2,735	3,218	2,772	2,907	3,420	205	215	253	49	51	60	1.2	3.3
344	Fabricated Structural Metal Products	21,504	25,153	30,310	25,131	29,287	35,291	771	899	1,083	187	218	263	3.9	3.8
345	Screw Machine Products, Bolts, etc.	4,396	5,006	5,608	5,409	6,159	6,901	160	182	204	39	44	50	3.3	2.3
346	Metal Forgings and Stampings	15,250	17,031	18,988	5,892	6,580	7,337	205	119	255	50	56	62	2.8	2.2
347	Metal Services	2,877	3,302	3,846	19,157	21,903	25,608	1,124	1,290	1,603	273	313	365	3.5	3.1
348	Ordnance and Accessories	2,804	3,071	3,358	132	145	158	5	5	6	1	1	1	2.3	1.8
349	Misc. Fabricated Metal Products	12,612	14,473	16,859	16,024	18,388	21,420	864	991	1,155	209	240	279	3.5	3.1
35	Non-Electric Machinery														
351	Engines and Turbines	9,009	10,992	14,503	792	966	1,275	33	40	53	6	7	10	5.1	5.7
352	Farm and Garden Machinery	10,534	12,610	14,832	8,238	9,862	11,600	304	364	420	65	78	92	4.6	3.3
353	Construction and Related Machinery	19,741	24,178	29,417	11,089	13,582	16,524	451	552	672	96	118	143	5.2	4.0
354	Metalworking Machinery	11,278	13,501	15,576	38,152	45,671	52,689	569	681	786	122	146	168	4.6	2.9
355	Special Industrial Machinery	9,454	10,476	12,085	10,467	11,599	13,381	41	45	52	9	10	12	2.6	2.9
356	General Industrial Machinery	14,196	18,609	25,496	30,734	40,286	55,195	1,876	2,459	3,369	402	527	722	7.0	6.5
357	Office and Computing Machines	13,722	18,258	23,976	4,589	6,106	8,018	220	293	384	47	63	82	7.4	5.6
358	Refrigeration and Service Machinery	10,660	12,712	16,071	6,005	7,256	9,173	169	202	255	35	42	53	4.5	4.8
359	Misc. Machinery, except Electrical	6,930	8,983	10,363	79,547	103,105	118,948	1,085	1,406	1,622	232	301	347	6.7	2.9
36	Electric Equipment														
361	Electric Distributing Equipment	4,648	5,505	7,333	3,945	4,633	6,171	871	1,023	1,362	115	135	180	4.1	5.9
362	Electrical Industrial Apparatus	8,453	10,752	12,957	4,138	5,264	6,343	279	355	428	36	46	55	6.2	3.8
364	Electric Lighting and Wiring Equip.	7,342	8,958	11,325	10,935	13,342	16,067	2,465	3,008	3,802	324	395	500	5.1	4.8
365	Communication Equipment	19,138	21,540	26,715	11,339	12,762	15,828	2,539	2,858	3,544	333	375	465	3.0	4.4
367	Electronic Components and Accessories	12,413	15,112	19,472	10,196	12,393	15,969	1,362	1,656	2,133	178	216	279	5.0	5.2
369	Misc. Electrical Equip. and Supplies	6,829	8,396	10,973	4,989	6,134	8,017	71	87	114	10	12	16	5.3	5.5
37	Transportation Equipment														
371	Motor Vehicles and Equipment	95,381	100,043	106,717	10,944	11,479	12,245	630	661	705	89	93	100	1.2	1.3
372	Aircraft and Parts	23,463	27,029	34,496	11,967	13,786	17,594	2,779	3,201	4,086	393	453	578	3.6	5.0
376	Guided Missiles, Space Vehicles, Parts	7,142	9,119	11,418	716	914	1,145	178	227	285	25	32	40	6.3	4.6
379	Misc. Transportation Equipment	3,117	3,980	4,983	4,358	5,564	6,968	0	0	0	0	0	0	6.3	4.6
38	Instruments and Clocks														
381	Engineering and Scientific Instruments	1,847	2,412	2,796	6,086	7,948	9,214	550	718	833	32	42	48	6.9	3.0
382	Measuring and Controlling Devices	6,180	8,071	9,356	17,797	23,241	26,943	3,196	4,171	4,835	187	244	283	6.9	3.0
39	Miscellaneous Industry	16,284	20,252	23,592	15,936	19,817	23,085	614	764	889	73	91	106	5.6	3.1
	Total Manufacturing	423,508	490,171	582,361	416,879	506,124	604,723	26,999	32,456	39,522	4,492	5,352	6,506	-	-
401	Railroads - Maintenance	18,536	20,222	22,000	1,161	1,267	1,378	61	67	73	0	0	0	2.2	1.7
458	Air Transport - Maintenance	3,701	4,998	6,784	36,160	48,832	66,278	3,279	4,428	6,010	0	0	0	7.8	6.3
753	Auto Repair	13,269	14,704	17,804	468,027	518,633	627,969	0	0	0	0	0	0	2.6	3.9
	General Industry Usage	-	-	-	345,773	403,262	480,571	0	0	0	0	0	0	3.92	3.57
	TOTAL	459,014	530,095	628,949	1,268,000	1,478,118	1,780,919	30,339	38,951	45,605	4,492	5,352	6,506	-	-

Source: Appendix F; References 5 and 7.

code industry. The total number of cold cleaners (CC) will increase by 16.6 percent from 1976 to 1980 and by 20.5 percent from 1980 to 1985. Manufacturing CC will increase by 21.4 percent and 19.5 percent for the two periods, while service CC will increase in number by 12.5 percent and 22.3 percent. General usage CC will increase by 16.6 percent and 19.2 percent for the two periods. Thus, for CC, the largest proportional increase is in manufacturing for 1976 to 1980 and in service uses for 1980 to 1985.

For open top vapor degreasers (OTVD) the largest percentage increase for each period is in service industries: 34.6 percent and 35.3 percent for 1976 to 1980 and 1980 to 1985, respectively. Analagous estimates for manufacturing are 20.2 percent and 21.8 percent. Note, however, that because most of the OTVD are located in manufacturing (manufacturing accounted for 89.1 of all OTVD in 1976), the total numbers of OTVD will increase only by 21.8 percent and 23.4 percent for the two periods. One interesting and important point is that OTVD are concentrated in industries whose projected growth rates are higher than for those in which CC are concentrated. Consequently, the percentage increase for OTVD is higher than for CC in each period. The rate of increase in conveyorized vapor degreasers is 19.1 percent for 1976 to 1980 and 21.6 percent for 1980 to 1985 and lies between the growth rates for CC and OTVD.

Within manufacturing industries, diverse growth rates yield diverse rates of increase in degreaser usage. The highest growth rates often occur in industries using small numbers of degreasers; for example, industries 351-Engines and Turbines and 376-Guided Missiles. Only one industry, 356-General Industrial Machinery, combines a larger number of degreasers with an unusually high growth rate. (Degreaser use in that industry rises by 80% over the period 1976 to 1985). Consequently, the rate of growth in degreasing activities will not differ significantly from the rate of growth of general economic activity.

Increased numbers of degreasers means increased solvent use, given a constant rate of solvent loss per degreaser. Under this assumption, which implies that firms do not implement NSPS controls to a greater extent than they already have, the percent increases in solvent use for 1976-1980 by SIC code industry are the industry growth rates for those periods presented in Table 8-6. Demand for solvents over the next ten years is therefore likely to be most buoyant in industries such as 356-General Industrial Machinery, 357-Office and Computing Machines, 361-Electrical Distributing Equipment and 351-Engines and Turbines where projected growth rates are high. It will be weak in industries such as 332-Iron and Steel Foundries and 348-Ordinance and Accessories where projected growth rates are low.

f) Qualifications

The projections of demand for degreasers presented above rest on two assumptions. The first is that degreaser usage by three-digit SIC code industries has been correctly identified; the second is the assumption of fixed input-output coefficients for degreasers. Both are questionable, but no less so than alternative assumptions.

Issue may be taken with the validity of the Dow national survey (Surprenant et al.[3]) though it covered 2,578 firms. The survey dealt only with organic solvent degreasing in metal working industries. Yet from the Eureka survey (Leung et al.[6]), it is clear that other sectors such as railroad and aircraft maintenance use vapor degreasers in addition to cold cleaners. Further, the survey only deals with cold cleaning systems in two-digit industries, not with total numbers of cold cleaners. The Eureka Laboratories survey is more detailed in the sense that it examines organic solvent degreasing at the three-digit code level, but less so in that it covers only eight two-digit SIC industries, omitting SIC Code Industry 39-Miscellaneous Industry. This two-digit industry was ignored because Eureka's provisional survey failed to indicate any usage of organic solvent degreasing equipment by firms in that industry. Yet Dow's survey shows that at least a small amount of organic solvent cleaning does take place in SIC 39. Further, Eureka's study covered only California, which may be an atypical state vis-a-vis organic solvent degreasing because of its relatively long history of state air pollution controls under which, for example, trichlorethylene was proscribed a decade ago.*

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*Rule 66 provisions, in operation in California since the mid-1960's were only adopted in 1974 by other states.

An additional problem is that Eureka's survey presented evidence only on solvent usage by each three-digit industry, not on numbers of different types of degreasers. Thus, variations in the percentage of emissions attributable to cold cleaners, open top vapor degreasers and conveyorized vapor degreasers across three-digit industries within given two-digit classes could not be identified. Consequently, appropriate adjustments could not be made for such variations in emissions in the estimation of the different types of degreaser used at the three-digit level. Despite the above qualifications, it should be noted that the data on location of organic solvent degreasers in the U.S. presented in the Dow and Eureka surveys are the most comprehensive sets currently available.

The fixed coefficient assumption used in the baseline projections of net investment in organic solvent degreasing must also be examined. In many plants, degreasing equipment is significantly underutilized.* This situation is not uncommon. Therefore, increases (decreases) in average plant size over time, measured by changes in real output, would imply increased (decreased) utilization of organic solvent degreasers and a consequent fall (rise) in degreaser input-output coefficients. Failure to take account of such changes would lead to errors in the projections presented above.

To test for the possibility of a persistent bias in the projections because of the fixed input-output coefficient assumption, historical trends in average plant size for metal working industries (SIC codes 25 and 33-39) were examined for the three periods 1963-67, 1967-72 and 1963-1972 using data from the Census of Manufactures.[9] Values of shipments for 1963 and 1967 were adjusted using the Wholesale Price Index by Commodities[9] published by the Bureau of the Census. The results are presented in Tables 8-7 and 8-8. From the summary Table 8-8, it can be seen that between 1963 and 1967 average plant sizes rose in 51 of 55 industries; however, between 1967 and 1972, this number fell to 29 of 56. Over the entire period, 1963-1972, plant size rose in 44 out of 55 industries. There is also considerable variation between industries and within industries between time periods. For example, in industry 386-Photographic Equipment and Supplies, average plant size rose by 470% over the period 1963-72; in another, 376-Guided Missiles, Space Vehicles and Parts, it fell to 51.8% of its original level over the same time period. Clearly, average plant output may rise or fall over time. In 25 of the 56 industries, the direction of change in average plant size shifted between 1963-67 and 1967-72, in some cases dramatically. For example, in industry 348-Ordnance and Accessories output per plant virtually doubled between 1963 and 1967, but fell to almost its original level in 1972.

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*At a Westinghouse plant in Raleigh, North Carolina, the open top vapor degreaser was used for less than 30% of one shift per day.

The historical evidence on average plant size suggests that all things are possible. Consequently, the assumption of no change is as satisfactory as any other. Hence the fixed input-output coefficients

Table 8-7. Average Plant Size by SIC 3-Digit Industries: 1963-1972.

SIC Code	Manufacturers of:	Average Plant Size by Value of Shipment (1972 Prices - Dollars x 10^3) 1963	1967	1972	Direction of Change in Average Plant Size 1963-67	1967-72	1963-72
251/2/3	Metal Furniture	936.8	1,255.9	1,616.2	+	+	+
254	Metal Partitions	418.3	571.5	759.7	+	+	+
259	Fixtures, Drapery, Hardware	343.5	510.7	737.2	+	+	+
331	Basic Steel Products	34,366.5	33,164.2	29,521.1	-	-	-
332	Iron & Steel Foundries	2,866.8	3,759.7	4,083.5	+	+	+
333	Primary Nonferrous Metals	35,172.8	29,413.8	34,103.4	-	+	-
334	Secondary Nonferrous Metals	3,081.2	4,860.3	5,504.5	+	+	+
335	Nonferrous Rolling & Drawing	14,623.3	14,714.9	14,259.6	+	-	-
336	Nonferrous Foundries	878.8	1,307.1	1,262.2	+	-	+
339	Misc. Primary Metal Products	510.8	744.9	731.9	+	-	+
341	Metal Containers	7,752.3	8,990.4	8,991.1	+	+	+
342	Cutlery & Handtools	1,831.0	2,365.9	2,675.6	+	+	+
343	Plumbing & Heating	1,972.5	2,180.7	2,822.7	+	+	+
344	Fabricated Structural Metal Products	937.7	1,271.3	1,369.9	+	+	+
345	Screw, Bolts	999.0	1,298.0	1,245.6	+	-	+
346	Metal Forging	2,597.1	3,046.1	3,123.2	+	+	+
347	Misc. Metal Services	265.3	332.9	364.7	+	+	+
348	Ordnance & Accessories (Guns & Munitions)	8,532.1	16,354.2	8,847.6	+	-	+
349	Misc. Fabrication Metal Products	1,312.8	1,683.8	1,493.1	+	-	+
351	Engines & Turbine	16,197.6	20,317.6	21,768.4	+	+	+
352	Farm & Garden Machinery	1,608.9	3,133.3	3,371.8	+	+	+
353	Construction & Related Machinery	2,601.7	4,023.0	4,405.8	+	+	+
354	Metalworking Machinery	670.3	938.2	752.9	+	-	+
355	Special Industry Machinery	1,283.9	1,777.4	1,684.5	+	-	+

Table 8-7 (continued)

SIC Code	Manufacturers of:	Average Plant Size by Value of Shipment (1972 Prices - Dollars x 10^3) 1963	1967	1972	Direction of Change in Average Plant Size 1963-67	1967-72	1963-72
356	General Industrial Machinery	1,617.8	2,170.9	2,183.2	+	+	+
357	Office & Computing Machines	*	11,375.1	8,648.1	*	-	*
358	Refrigeration & Service Machinery	2,502.4	3,381.5	4,924.3	+	+	+
359	Misc. Machinery except Electrical	215.4	289.7	268.9	+	-	+
361	Electrical Distributing Equipment	4,088.7	5,402.7	4,573.2	+	-	+
362	Electrical Industrial Apparatus	3,292.5	4,430.4	3,577.7	+	-	+
363	Household Appliances	7,640.9	10,548.1	10,760.2	+	+	+
364	Electric Lighting & Wiring Equipment	1,913.1	2,599.1	2,978.8	+	+	+
365	Radio & TV Receiving Equipment	6,140.5	7,864.9	5,333.1	+	-	-
366	Communication Equipment	9,439.3	10,026.0	6,915.5	+	-	-
367	Electronic Components & Accessories	2,216.2	3,853.2	3,078.4	+	-	+
369	Misc. Electrical Equipment & Supplies	2,846.2	2,989.5	2,612.0	+	-	-
371	Motor Vehicles & Equipment	14,939.7	17,146.3	18,850.3	+	+	+
372	Aircraft & Parts	11,842.6	19,267.6	14,479.8	+	-	+
373	Ship & Boat Building & Repairs	1,210.1	1,746.8	1,939.6	+	+	+
374	Railroad Equipment	15,559.1	19,509.0	15,007.4	+	-	-
375	Motorcycles, Bicycles & Parts	2,548.3	3,743.4	2,970.7	+	-	+
376	Guided Missiles, Space Vehicles, Parts	113,697.5	81,173.5	58,908.6	-	-	-
379	Misc. Transportation Equipment	1,542.0	1,703.4	1,461.0	+	-	-
381	Engineering & Scientific Instruments	1,192.5	1,742.9	1,402.4	+	-	+
382	Measuring & Controlling Devices	2,319.7	2,926.9	2,478.2	+	-	+
383	Optical Instruments & Lenses	1,538.8	1,897.0	1,089.9	+	-	-
384	Medical Instruments & Supplies	1,000.9	1,233.5	1,573.0	+	+	+
385	Ophthalmic Goods	1,522.6	1,089.6	1,138.9	-	+	-

*Incomplete data for SIC 357.

Table 8-7 (concluded)

SIC Code	Manufacturers of:	Average Plant Size by Value of Shipment (1972 Prices - Dollars x 10^3)			Direction of Change in Average Plant Size		
		1963	1967	1972	1963-67	1967-72	1963-72
386	Photographic Equiment & Supplies	1,906.5	7,756.6	8,969.5	+	+	+
387	Watches, Clocks & Watchcases	3,166.8	4,240.8	4,639.6	+	+	+
391	Jewelry, Silverware & Plated Ware	590.7	725.3	789.4	+	+	+
393	Musical Instruments	1,329.1	1,563.7	1,795.1	+	+	+
394	Toys & Sporting Goods	918.6	1,120.0	1,488.9	+	+	+
395	Pens, Pencils, Office & Art Supplies	796.5	932.2	959.3	+	+	+
396	Costume Jewelry & Notions	533.0	712.2	842.6	+	-	+
399	Miscellaneous Manufactures	440.5	515.2	511.2	+	-	+

Table 8-8. Summary of Trends in Average Plant Size, 1963-1972*

Time Period	# of industries where plant size increased	# of industries where plant size decreased
1963-1967	51	4
1967-1972	29	27
1963-1972	44	11

*Based on data presented in Table 8.1.6.1.

used in the baseline projections of demand for organic solvent degreasers are not unreasonable even if they are not perfect.

8.1.3 Market Conditions

8.1.3.1 Demand for Solvents

The demand for organic solvents is not limited to metal cleaning operations. Other industrial applications for the solvents used in cold cleaning include: surface coatings and resins, octane additives, organic chemical synthesis, plastics production, and textile/pharmaceutical processing.

With the exception of trichloroethylene, the solvents utilized in vapor degreasing also have additional applications. Perchloroethylene is used in dry cleaning (63%), trichlorotrifluoroethane production (11%), exports (7%) and miscellaneous products (3%). Organic solvent cleaning holds only a small percentage of the market for this compound (16%). Uses of trichlorotrifluoroethane besides cleaning (72%) include: chemical processing (5.2%) carrier medium (4.1%), drying (5.6%), cutting fluid (2.4%), dry cleaning (3.4%), miscellaneous (0.6%) and government (6.7%). Methylene chloride also has a variety of uses - plastics, paint remover and aerosol propellant production (40%), exports (19%), aerosol vapor pressure depressant (17%), plastics processing (6%), and "other" (19%). In the past, the degreasing industry had consumed only a small part of the total methylene chloride output; presently, the use of this compound has increased as a substitute for trichloroethylene. Approximately 75% of 1,1,1-trichloroethane is used in metal cleaning, while the remaining 25% is divided between the following uses; aerosol propellants, vinyl chloride production, and other miscellaneous categories.

Several other factors influence the demand for solvents in degreasing operations (see Table 8-9 for solvent prices and consumption data). The degreasing industry, in general, can be classified as an industrial services industry. As such, the future expanded use of solvent degreasing systems (and the growth of the degreasing industry) is directly related to the growth and expansion of the semi-finished and finished productions manufacturers.

Environmental and health regulations issued by the EPA, OSHA and state governments can have an impact on the demand for degreasing solvents. Regulations can alter demand by placing limitations or an outright ban on the use of certain solvents. Federal or state emission control requirements could lead to the closing of marginally economic degreasing operations, thus, reducing total solvent consumption. These regulations could also reduce solvent demand by allowing companies to use recovered solvent from carbon adsorbers, instead of consuming newly produced solvents.

An additional factor that may have an influence on the demand for degreasers is the availability and cost competitiveness of substitute technologies such as alkaline washing. However, according to industry sources,[1,2] the opportunities available for the substitution of organic solvent cleaning operations with alkaline washing systems are very limited. Thus a significant variation in the cost competitiveness of alkaline washing processes may have little impact on the demand for solvents used in the degreasing industry.

The price of substitute solvents is another factor that affects the total demand for degreasing solvents. This demand determinant is covered in Section 8.1.3.3.

8.1.3.2 Substitution of Solvents

Trichloroethylene and 1,1,1-trichloroethane are close technological substitutes. Both have relatively low boiling points (80°C and 74°C, respectively) and may be used in ordinary industrial operations.[14] While they are not perfect substitutes*, it can be expected that an increase in the user cost for one, would lead to an increase in demand for the other. This was the case following the classfication of trichloroethylene as a nonexempt chemical under L.A. Rule 66. Since this ruling in 1966, many industrial operations have replaced trichloroethylene with 1,1,1-trichloroethane. This trend could be slowed or even reversed if regulatory restrictions were placed on the use of 1,1,1-trichloroethane.

In recent years, there has been an increase in the use of methylene chloride in solvent degreasing operations. One reason for this change in solvent consumption patterns is that methylene chloride can be substituted for trichloroethylene and 1,1,1-trichloroethane in some industrial degreasing processes. It is, however, relatively expensive to use due to a rapid diffusion rate[3] and the fact that a change to methylene chloride requires extensive modifications in the degreasing systems, which were designed for use with other solvents.

Perchloroethylene, which is an imperfect substitute for the other solvents, is used when a high boiling point (121°C) is required for greater cleaning efficiency or when water is present on the cleaning surface. It is less desirable to use this solvent for ordinary industrial degreasing operations due to increased energy costs and parts handling problems associated with higher operating temperatures. Although perchloroethylene is used in 15 percent of all vapor degreasing operations, it is a suspected carcinogen. This problem could have a major impact on future industrial uses of perchloroethylene.

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*1,1,1-trichloroethane has problems reacting with zinc and aluminum and cannot be applied when there is excess water on the cleaning surfaces.

Trichlorotrifluoroethane (the most common freon-based degreasing solvent) is particularly suited for cleaning small, delicate parts which cannot tolerate high temperatures. Due to its rapid diffusion rate and relatively high price (Table 8-9), the solvent is usually used only when a task requires its special degreasing properties.

8.1.3.3 Solvent Prices

As a group, the halogenated solvents are more expensive to use than petroleum solvents, alcohols and toluene. These latter solvent groups are unsuited for vapor degreasing processes due to their low flash point temperatures. However, their lower prices make them preferred to halogenated solvents in cold cleaning operations. Even though acetone and ketones are more expensive than petroleum solvents, they are sometimes used in cold cleaners to attain higher cleaning efficiences.

Fluorocarbons (freon-based solvents) have a much higher unit price compared to other solvents. Due to this price disadvantage, it is uneconomic to use these solvents in ordinary degreasing processes.

Table 8-9. Solvent Use in Room Temperature Cleaning in the Metalworking Industry

Solvent	# of plants using, 1974	10^3 Kg/yr, 1974	price/Kg $, 1974	price/Kg $, 1978	Estimated value in cold degreasing $ x 10^3, 1974
trichloroethylene	2,295	19,530	0.57	0.46	11,195
1,1,1-trichloroethane	2,106	30,596	0.55	0.53	16,863
perchloroethylene	702	4,316	0.55	0.37	2,379
methylene chloride	324	3,114	0.57	0.46	1,785
fluorocarbons	1,026	8,845	1.83	1.23	16,185
petroleum solvents	6,344	33,267	0.22- 0.33	0.15	9,100
acetone	1,215	3,592	0.51	0.40	2,003
methyl ethyl ketone	648	3,090	0.57	0.46	1,771
toluene	837	5,408	0.26	0.22	1,431
alcohols	945	2,766	0.37- 0.53	0.18- 0.37	1,220
safety blends	2,079	7,248	NA	NA	NA

Source: Reference 3

8.2 COST ANALYSIS OF ALTERNATIVE EMISSION CONTROL SYSTEMS

8.2.1 New Facilities

8.2.1.1 Introduction

The purpose of this section is to develop estimates of capital and annualized costs of alternative control systems for reduction of volatile organic compound (VOC) emissions from new solvent cleaning facilities. The cost to achieve various levels of control will be presented for model affected facilities representative of the three types of degreasers under investigation. For the solvent cleaning industry, requirements for compliance with state regulations for control of VOC emissions were assumed to be negligible. However, states currently are in the process of drafting regulations which will require some controls on degreasers. With regard to OSHA standards, there does not appear to be any significant equipment requirements for compliance. The total cost requirements presented will be the incremental control costs over state and OSHA regulatory requirements.

Throughout this chapter the terms capital and annualized costs are used; therefore, a brief explanation of each is in order. The capital cost includes all the costs necessary to design, purchase, and install the particular system (e.g., refrigerated freeboard device) or equipment addition (e.g., degreaser cover). The capital cost includes the purchased cost of the major control device, such as the refrigerated freeboard device coils and compressor; any auxiliaries, such as a fan or steam boiler for a carbon adsorber; any installation involving foundations, building space requirements, and electrical wiring; and cost of engineering services, contingencies, start-up, sales tax, and freight costs. The sources of the control cost information are provided wherever appropriate. All costs are in terms of second quarter 1978 dollars.

The annualized costs of a control system are what it costs the individual plant to own and operate that control system on a yearly basis. The annualized costs include direct operating costs such as energy, other utilities, maintenance, operating labor, and capital related charges such as capital recovery, property taxes, and insurance. Whereas actual costs experienced by individual plants in the operation of degreasers can vary, the following values were selected as typical and should provide a reasonable estimate of the annualized costs of the control systems:

(a) Electricity costs at 4.3 cents per kilowatt-hour[17]

(b) Steam cost at $7.26 per 1000 kilogram of steam[18]

(c) Building space cost at $35 per square foot[19]

(d) Cooling water costs at 7 cents per 1000 gallon[20]

(e) Mineral spirits recovery credit at 21 cents per kilogram[21]

(f) Trichloroethylene recovery credit at 45 cents per kilogram[22]

(g) Maintenance cost at 4 per cent of capital

(h) Taxes, insurance, and administrative costs at 4 per cent of capital

Capital recovery charges are based on annualization of the control system over its economic life and a ten per cent interest rate. The economic lives of the control systems presented in this chapter are assumed to be 15 years.

An important element in the determination of the annualized costs are the annual operating hours and credits for recovered solvent. For this analysis, 2080 operating hours were assumed per annum, based on an 8-hour shift and 260 operating days. The amount of the recovered solvent credit depends upon the operating hours, solvent type, and operating mode. More information will be presented on the operating mode in the discussion of model plant parameters for the various types of degreasers. The value of solvent assumed to be recovered is based on the use of two types of solvents for the three types of degreasers discussed further in this chapter. Prices used in determining credits for mineral spirits and trichloroethylene are presented above.

8.2.1.2 Alternative Controls

There are two types of controls that can be used in minimizing organic solvent cleaning emissions -- housekeeping or operating practices that entail minimal cost and methods or procedures that incur direct costs. Housekeeping practices include the operation of safety covers installed on tanks, preventing spillage of solvents on the work area floor, and storing waste solvent in closed containers. No incremental costs for housekeeping controls are presented in this chapter. A reasonable judgment is that such costs are negligible, particularly considering that they are offset by savings in recovered additional solvent from improved housekeeping.

The scope of this chapter will encompass only specific equipment features and control devices that can be designed or added on to new degreasing equipment. There are four major demonstrated emission control technologies, these being:

(a) Covers for cold cleaners and open top vapor degreasers (OTVD),

(b) Increased freeboard ratio for OTVD,

(c) Refrigerated freeboard devices for OTVD and conveyorized degreasers (CD), and

(d) Carbon adsorbers for OTVD and CD.

In addition, drainage racks are effective for reducing emissions from carry-out losses in cold cleaning operations. Also, drying tunnels can be effective in reducing emissions during the operation of monorail conveyorized vapor degreasers. Drainage racks and drying tunnels will be included in the cost analysis.

8.2.2 Cold Cleaners

8.2.2.1 Model Plant Parameters

The model parameters that were used in developing control costs for cold cleaners are shown in Table 8-10. These parameters are based on industry contacts and EPA studies of the solvent degreasing industry. The most common type of cleaning is performed with

Table 8-10. COST PARAMETERS FOR MODEL COLD CLEANERS

	Typical Size	Large Size
Working Area, m^2	0.40	1.2
Solvent Used	Mineral Spirits (38.9°C)	Mineral Spirits
Uncontrolled Emission Rate		
a) Vaporization, kg/yr	413	1239
b) Carry-out losses, kg/yr	74	74
Controlled Emission Rate		
a) Vaporization, kg/yr	63	189
b) Carry-out losses, kg/yr	37	37
Solvent Recovered by Control		
a) Cover, kg/yr	350	1017
b) Drainage Rack, kg/yr	37	37

mineral spirits. The uncontrolled emission rates in Table 8-10 represent a typical mode of operation, based on the following:

(a) Twenty loads processed per day for a period of 2 hours per day (uncovered).

(b) The degreaser remains uncovered during the remaining operating day, nights and weekends.

The uncontrolled emission rates are based on a vaporization rate of 0.118 kg/hr-m^2, as determined by EPA emission studies,[23] and 14.2 grams per load for emission carry-out loss.

The controlled emission rates represent the following:

(a) Utilizing the cover when the degreaser is not in use with a control efficiency of 90 per cent for 8240 hours per year.

(b) Utilizing the drainage rack with a 30-second drain time for 520 hours per year with a control efficiency of 50 per cent, the latter based on emission testing studies performed by EPA.[24,25]

8.2.2.2 Costs

A summary of capital and annualized control costs is presented in Table 8-11. The control system consisted of a spring-loaded, counterweighted cover to reduce vaporization losses and a drainage rack to reduce carry-out losses. The capital costs are based on information received from a major manufacturer of cold cleaners.[26] A review of the table shows that credits for recovered solvents as a result of the controls are significantly greater than the annualized costs associated with the ownership and operation of the control

Table 8-11. COSTS OF CONTROLS FOR MODEL COLD CLEANERS

	Typical Size ($0.4\ m^2$)	Large Size ($1.2\ m^2$)
Base Capital Without Controls ($)	400	800
Installed Capital ($)	51	104
a) Cover	25	78
b) Drainage Rack	26	26
Total Annualized Costs	(70)	(220)
a) Direct operating costs	-0-	-0-
b) Capital charges, taxes, insurance, administrative	8.75	17.84
c) Solvent credit	(79.00)	(237.00)
Controlled emissions (kg/yr)	376	1128
Cost (Credit), $ per kg controlled	(0.187)	(0.194)

system. The result is a net credit of approximately $0.19 per kilogram solvent recovered for the typical cold cleaner and approximately $0.20 per kilogram for the large-sized degreaser.

8.2.3 Open Top Vapor Degreasers

8.2.3.1 Model Plant Parameters

The model plant parameters that are used in developing control costs for open top vapor degreasers (OTVD) are presented in Table 8-12. These parameters are based on industry contact wand EPA studies on OTVD. Trichoroethylene is a common solvent used for vapor degreasing. The cost analysis is based on the use of this solvent. The uncontrolled emission rates in Table 8-12 represent a typical mode of operation, based on the following:

(a) During the 8-hour working day, the degreaser is hot and is assumed to be uncovered and working for six of these hours (75 per cent of the working day).

(b) The degreaser is idle for the remaining two hours (25 per cent of the working day) and remains uncovered.

(c) The vaporization rate is 1.82 kilogram/hr-m^2 for a hot degreaser with a freeboard ratio of 0.5.[27]

(d) The carryout loss is 1.47 kilogram/hr-m^2.[28]

(e) No emissions are assumed to occur during non-working hours as the degreaser solvent is not boiling and is contained or covered.

Table 8-12. ENGINEERING PARAMETERS FOR MODEL OPEN TOP VAPOR DEGREASERs (OTVD)

	Small OTVD		Typical OTVD			Large OTVD		
Working area (m^2)	0.93 (10 ft^2)		1.86 (20 ft^2)			5.58 (60 ft^2)		
Solvent	Trichloroethylene		Trichloroethylene			Trichloroethylene		
Uncontrolled emissions (kg/yr)								
vaporization	3,521		7,041			21,124		
carryout	2,133		4,265			12,796		
Emission Reduction (kg/yr)	Cover + Freeboard	Cover + Ref. Free. Device	Cover + Freeboard	Cover + Ref. Free. Device	Cover + Carbon Adsorber	Cover + Freeboard	Cover + Ref. Free. Device	Cover + Carbon Adsorber
By cover	581	316	1,162	632	1,493	3,486	1,896	4,480
By second system	733	2,058	1,466	4,116	4,570	4,398	12,347	13,700
TOTAL	1,314	2,374	2,628	4,748	6,063	7,884	14,243	18,180

The emission reductions shown in Table 8-12 are based on the following assumptions:

(a) Utilizing a cover with a control efficiency of 90 percent during idle time (2 hours per shift).

(b) Reduction of 27 percent in vaporization losses for the increased freeboard (ratio of 0.75)

(c) Reduction of 60 percent[29,30] in vaporization losses and 20 percent[31] in carryout losses associated with the use of a refrigerated freeboard device.

(d) Reduction of 70 percent[32] in vaporization losses and 30 percent[33] in carryout losses associated with the use of a carbon adsorber.

The most common OTVD sold is a degreaser with a working area of approximately 2 square meters (20 square feet). This size of degreaser is presented as the typical cleaner in Table 8-13. The two other model cleaners are presented to indicate the spectrum in terms of working area size.

Another feature of OTVD is that the number of shifts and degree of utilities will vary throughout the solvent cleaning industry. Two or three shifts per day can be used; idle time can vary from a likely estimate of 25 percent to perhaps 75 percent. The combination of one shift and an idle time of 25 per cent was chosen for what is believed as a typical operating mode in the solvent cleaning industry.

Table 8-13. COSTS OF ALTERNATIVE CONTROLS FOR OPEN TOP VAPOR DEGREASERS

	Small Degreaser		Typical Degreaser			Large Degreaser		
Working Area, m^2	0.93 (10 ft^2)		1.86 (20 ft^2)			5.58 (60 ft^2)		
Base Capital(1),$ (w/o controls)	4,365		5,520			10,650		
	Cover + Freeboard	Cover + Ref. Free. Device	Cover + Freeboard	Cover + Ref. Free. Device	Cover + Carbon Adsorber	Cover + Freeboard	Cover + Ref. Free. Device	Cover + Carbon Adsorber
Installed Control Capital ($)	1,606	5,110	2,362	6,460	17,475	4,482	11,330	26,190
Total Annualized Costs ($/yr)	(278)	80	(721)	(671)	1,180	(2,661)	(3,749)	(1,883)
(a)Utilities ($/yr)	0	67	0	100	212	0	200	758
(b)Maintenance($/yr)	38	204	56	258	699	102	453	1,048
(c)Capital Recovery($/yr)	211	672	311	850	2,298	603	1,490	3,444
(d)Taxes, Insurance, Adm.	64	204	95	258	699	183	453	1,048
(e)Solvent Credit ($/yr)	(591)	(1,068)	(1,183)	(2,137)	(2,728)	(3,548)	(6,409)	(8,181)
Controlled emissions, kg/yr	1,314	2,374	2,628	4,748	6,063	7,884	14,243	18,180
Cost (Credit), $ per kg	(0.21)	0.03	(0.28)	(0.14)	0.19	(0.34)	(0.26)	(0.10)

8.2.3.2 Costs

A summary of the capital and annualized control costs for OTVD is presented in Table 8-13. The basis for determining the costs for increased freeboard height, covers, and refrigerated freeboard devices is the working area of the degreaser. For carbon adsorbers, design considerations are based on the amount of solvent emissions generated at an exhaust rate of 15 cubic meters per minute per square meter (50 cfm per ft^2) of degreaser area.[34] Sources of cost information were manufacturers of degreaser covers,[35] freeboards,[36] and refrigerated freeboard devices.[37] Carbon adsorber costs were obtained from manufacturer.[38] The capital costs for the controls include freight, installation, and sales taxes. It was assumed that a 15 percent charge added to the list price of control equipment would cover freight, sales taxes, and insurance. This assumption is based on contacts with industry vendors.

Capital costs for basic degreasing equipment (without controls) are also shown in Table 8-13. These are list prices based on heavy duty, single sump degreasers.[39] OTVD are sold in a variety of models. For single sump models, their price range from $1200 for a very small degreaser (approximately 0.5 square meter) to $5300 for an approximate 4 square meter (large) degreaser. Two sump models are approximately twice as expensive, and three sump models are about three times as expensive as single sump units. OTVD equipped with ultrasonic cleaners are considerably more expensive; a very small two sump model of approximately 0.6 square meter may cost nearly $11,000.

The annual capital cost recovery for carbon adsorbers shown in Table 8-13 includes an estimate for building space requirements. For example, building space is $2000 for the carbon adsorber on the typical degreaser; $4600 for the large degreaser. The basis for these costs is $35 per square foot cited earlier. Manufacturers of carbon adsorbers provided estimates of building space requirements.

In reviewing Table 8-13 for the annualized costs, one can observe that the cost of control systems generally are more than offset by the recovered solvent credits. The exceptions are the refrigerated freeboard device on the small degreaser and the carbon adsorber on the typical degreaser. (The annualized cost of a carbon adsorber before solvent credit would be approximately the same for the small degreaser as for the typical degreaser, but solvent credits would only be half as much as for the typical degreaser.) The results of controlling emissions using a freeboard and cover are a net credit of $0.21 per kg of solvent recovered for small degreaser to a credit of $0.34 per kg of solvent recovered for the large model. The results for using the refrigerated freeboard device are a cost of $0.03 per kg solvent recovered for the typical model and a credit of $0.26 per kg solvent recovered for the large unit. The carbon adsorber and cover result in a cost of $0.19 per kg for the typical unit and a net credit of $0.10 per kg for the large unit. These results are derived from an analysis which also includes the solvent savings due to the cover.

8.2.4. Conveyorized Vapor Degreasers (CVD)

8.2.4.1 Model Plant Parameters

The model plant parameters that were used in developed control costs for conveyorized degreasers are presented in Table 8-15 for monorail and crossrod designs. These parameter selections are based on industry contacts and EPA studies of the industry, in the same manner as cold cleaners and open top vapor degreasers. The emission rates in Table 8-15 represent typical values. The working area is used to determine costs for refrigerated freeboard devices. The assumption used to estimate refrigerated freeboard device costs is that the cost of the device for a CVD is equal to that for an OTVD of twice the area.[40] The recovered solvent values and the cost of solvent are used to estimate solvent credits which will reduce the annualized control costs of the control devices. The emission control estimates on which the analysis is based are given in Table 8-14. The CVD is assumed to run one shift, 260 days/year.

Table 8-14. EMISSION CONTROL ESTIMATES FOR CVD

Solvent concentations[41]	
Crossrod	750 ppm
Monorail	900 ppm
Monorail and drying tunnel	1,125 ppm
Reduction in solvent loss (adsorber)	
Crossrod[42]	50%
Monorail[42]	60%
Monorail and drying tunnel[16]	75%
Reduction in loss (refrigerated freeboard device)[43]	40%
Kilograms steam/kilogram solvent[45]	3
Ventilation rate (m^3/min per m^2)[45]	20

Table 8-15. ENGINEERING PARAMETERS FOR MODEL CONVEYORIZED VAPOR DEGREASERS (CVD)

	Crossrod + ref. free. device	Crossrod + adsorber	Monorail + adsorber	Monorail, adsorber, drying tunnel
Working Area (m^2)	4.65(50 ft^2)	4.65(50 ft^2)	4.65(50 ft^2)	4.65(50ft^2)
Solvent	Trichloroethylene	Trichloroethylene	Trichloroethylene	Trichloroethylene
Uncontrolled emissions (kg/yr)	28,850	29,120	28,950	38,950
Emission reduction (kg/yr)	11,540	14,560	17,370	21,710

8.2.4.2 Control Costs

Costs for control of emissions from conveyorized degreasers have been developed for the following control devices:

- Carbon adsorbers
- Refrigerated freeboard devices.

Table 8-16 presents the costs for the model conveyorized degreasers. Costs are presented in terms of installed capital costs, annualized costs, and the cost per kilogram of solvent controlled. Costs are presented for a crossrod with a refrigerated freeboard device, a crossrod and a monorail with carbon adsorbers and a monorail with a drying tunnel and an adsorber.

Installation of an adsorber saves from $0.12 to $0.19 while installation of a refrigerated freeboard device saves even more per kilogram controlled. A drying tunnel also reduces solvent losses if the work being degreased is so physically configured as to cause excessive carryout loses.

All savings are computed on the basis that desorption steam is available and that excessively long runs of exhaust ducts and insulated steam pipes are not required.

8.2.5 Cost Effectiveness

8.2.5.1 Open Top Vapor Degreasers

The purpose of this section is to provide a graphical analysis of the cost-effectiveness of alternative control options to various types of open top vapor degreasers. This analysis will attempt to

Table 8-16. COSTS OF ALTERNATIVE CONTROLS FOR CONVEYORIZED VAPOR DEGREASERS

	Crossrod and Refrigerated Freeboard Device	Crossrod and Adsorber	Monorail and Adsorber	Monorail, Adsorber, Drying Tunnel
Base Capital Cost ($)	38,000	38,000	47,000	47,000
Control Cost ($)	11,490	19,860	19,860	23,420
Total Annualized Cost ($/yr)	(2,428)	(1,679)	(2,880)	(4,126)
(a) Utilities	334	673	737	833
(b) Maintenance	460	794	794	794
(c) Capital Recovery	1,511	2,612	2,612	3,080
(d) Taxes, Insurance	460	794	794	937
(e) Solvent Credit	(5,193)	(6,552)	(7,817)	(9,770)
Emission Reduction (kg/yr)	11,540	14,560	17,370	21,710
Cost/credit ($/kg)	(0.21)	(0.12)	(0.17)	(0.19)

relate the annualized cost per kilogram of solvent removal with degreaser size for each control option.

Figure 8-1 is a presentation of the typical relationship for control of solvent emissions from open top vapor degreasers. Curves are shown for carbon adsorbers, refrigerated freeboard devices, and extended freeboards. In addition, all OTVD are equipped with covers. The size range shown in Figure 8-1 represents the approximate range of most degreasers (0.5 square meters to 25 square meters) based on EPA data, contractor studies, and contacts with degreaser manufacturers. The costs/kg of the control devices shown represent the capability of the control device for reducing emissions from a well maintained degreaser assuming all good housekeeping practices are followed. Although detailed costs are presented for three model degreasers in Section 8.2.3 several more estimates were derived in order to define the curves with reasonable precision.

An important concept of degreaser emission controls is the fact that credits for recovered solvent frequently offset the annualized costs of installing, operating, and maintaining a control device. In reviewing Figure 8-1, one can observe the extent to which solvent credits can more than offset the annualized costs of the control device. This is graphically illustrated by the horizontal breakeven line. This line indicates that application of carbon adsorbers will result in an out-of-the-pocket expense to the operator of a degreaser which is less than approximately 3.4 square meters in working area.

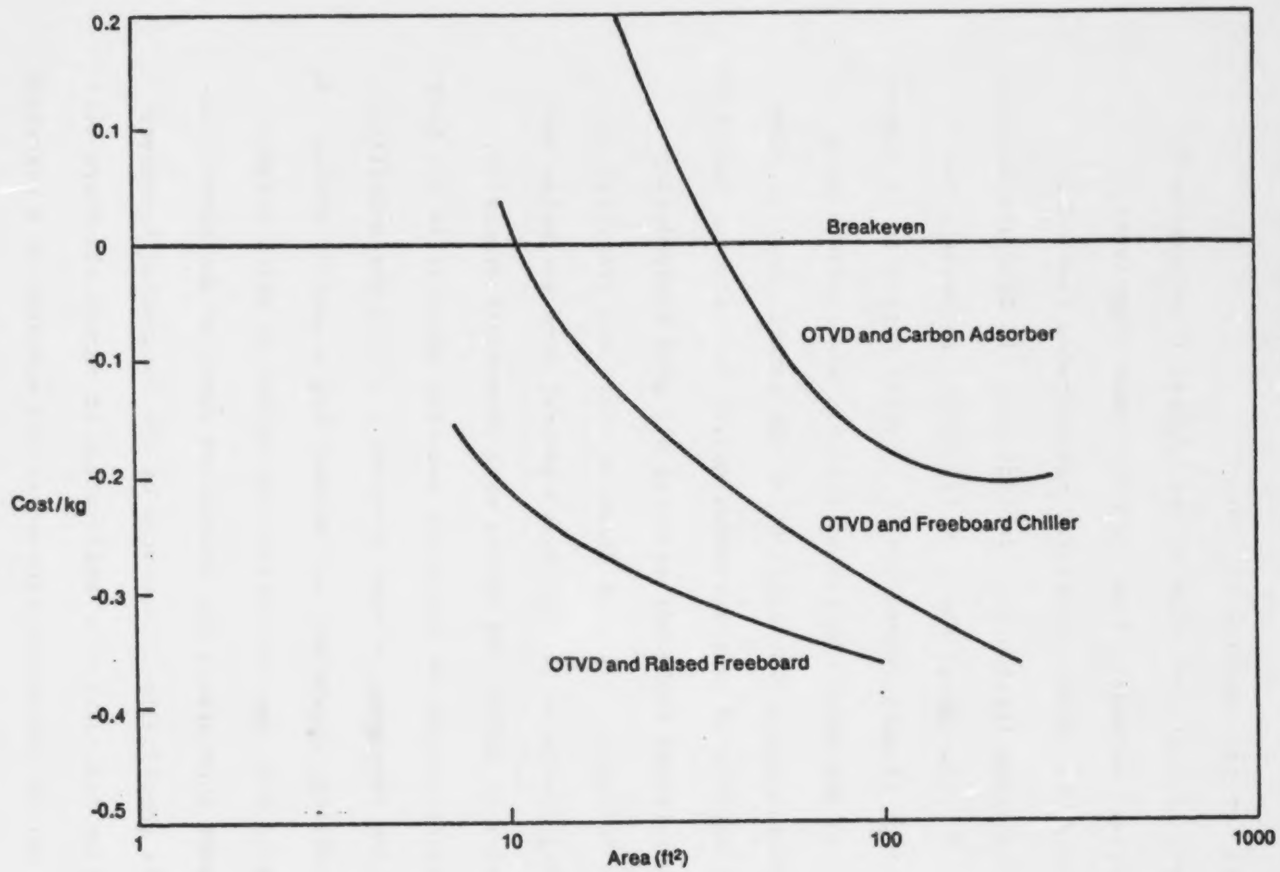

FIGURE 8-1
COST EFFECTIVENESS OF CONTROL OPTIONS
FOR OPEN TOP VAPOR DEGREASERS

Similarly, refrigerated freeboard devices will have the same result for degreasers smaller than approximately one square meter. Freeboard ratios of 0.75 seem to always be a worthwhile investment provided that the raised freeboard can be installed without having to lower the degreaser by digging a pit.

8.2.5.2 Conveyorized Vapor Degreasers

This section provides a graphical analysis of the cost-effectiveness for alternative control options on conveyorized degreasers. This analysis will relate the annualized cost per kilogram of solvent control to degreaser size for each control option.

Figure 8-2 shows a relationship of cost versus size for carbon adsorbers and refrigerated freeboard devices on monorail degreasers. The assumptions regarding the size range and control efficiencies are similar to those outlined for open top degreasers. The size range of most monorail degreasers is 2.3 to 25 square meters. As shown in Figure 8-2, the application of carbon adsorption results in an out-of-the-pocket expense for crossrod degreasers smaller than approximately 3 square meters in working area. Carbon adsorbers are quite cost effective for monorail degreasers, particularly larger ones if steam boilers do not have to be installed.

8.2.6 Modified and Reconstructed Facilities

Each modified and reconstructed facility will be a special case, therefore no specific cost estimates can be given. In the case of a raised freeboard for an OTVD, the cost analysis was based on the use

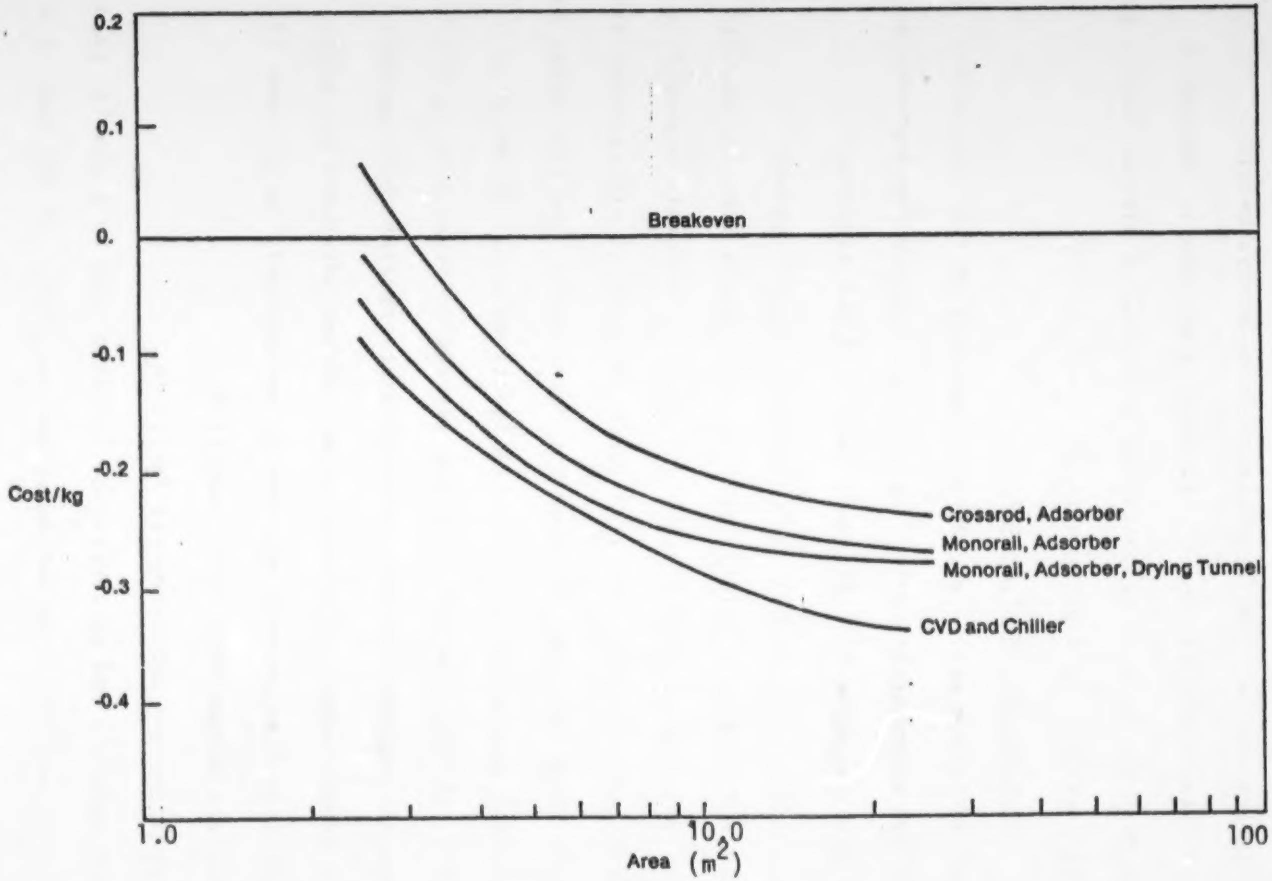

FIGURE 8-2
COST EFFECTIVENESS OF CONTROL OPTIONS FOR CONVEYORIZED VAPOR DEGREASERS

of a catwalk to allow workers to see into the degreaser. However, if the ceiling height is too low to permit raising the freeboard, a pit may have to be excavated and the OTVD lowered. Excavation costs will depend on building construction, access to the OTVD, size of the OTVD, ventilation requirements for the pit, and the need to install pit drainage. These costs are not quantifiable but they will be at least comparable with the cost of the OTVD and may be considerably larger.

Similar remarks can be made concerning carbon adsorbers. Current technology requires the use of steam for desorption. If a boiler does not exist at the plant, acquisition costs may be considerable. In addition, since desorption is intermittent, the boiler will be hot but idling much of the time depending on the degreaser load and adsorber size. This means the cost of steam will increase considerably over the estimate in Section 8.2.1.1. If building space is not available near the degreaser, the adsorber may have to be raised on a platform if ceiling height permits. The cost of a raised iron grating platform with attendant catwalks and ladders will depend on the adsorber size but in any case will be well over $1000. If the adsorber has to be located away from the degreaser and/or boiler, the cost of ducting and insulated steam pipes will be a major factor.

In summary, if installation of emission controls on degreasers requires substantial changes or additions to normal installation practices, it may be expected that the added costs may be 100 percent larger than the costs of controlling new sources. Information received from degreaser manufacturers indicates that major modification of an existing degreaser is a rare occurrence. The one exception is the installation of a refrigerated freeboard device on an OTVD. This practice is becoming more prevalent, and the costs are only slightly higher than factory installation on a new degreaser.

8.3 OTHER COST CONSIDERATIONS

Currently, no regulations exist concerning the discharge of condensate saturated with solvent from a carbon adsorber. In the event that such regulations are promulgated and that they affect condensate discharge from adsorbers, an additional control may be required to remove the solvent from the condensed steam before it is discharged. It may be possible to recycle the condensate through the boiler. No data exist on the effect of solvent in boiler feedwater on boiler performance, corrosion, or two-phase flow in the boiler tubes. Safety must be considered since most halogenated solvents present a fire hazard. Their presence in a boiler may not be permissible due to OSHA or other regulations.

If discharge of steam condensate containing solvent is prohibited at some time in the future, contract hauling may be used for disposal of the steam condensate. Based on a contract hauling cost of $0.30 per gallon, the cost of hauling the steam condensate from one desorption cycle for an average-sized carbon adsorber will be about $22.50.

Regulations pertaining to effluents from carbon adsorbers are not likely to be promulgated in the future. Therefore, an economic impact analysis of such regulations has not been done.

There is not expected to be an incremental increase in the amount of waste solvent disposed due to the implementation of this standard of performance. Methods requiring proper transportation and disposal of hazardous wastes are presently regulated by the Department of Transportation (DOT) and the Resource Conservation and Recovery Act (RCRA). The limitations imposed by this standard of performance would not increase the amount of waste disposed. The additional limitations would require generators of less than 100 kg of waste solvent per month to containerize their waste prior to landfilling. Since DOT already has containerization requirements for transporting hazardous waste, and since RCRA requires landfilling, the additional costs of this standard would be zero.

8.4 ECONOMIC IMPACT OF ALTERNATIVE EMISSION CONTROL SYSTEMS

8.4.1. Introduction

In this section the economic impacts of three regulatory control options for organic solvent degreasers are analyzed under two sets of market conditions. The alternative control options are as follows:

Option 1

(a) Cold Cleaners (CC). Cold cleaners are required to have an easily closeable cover and an external drain in which drying parts may be

(b) Open Top Vapor Degreasers (OTVD). OTVD are required to have an easily closeable cover and a freeboard ratio of 0.75.

(c) Conveyorized Vapor Degreasers (CVD). CVD are required to have a carbon adsorber to control emissions from vaporization and carry out.

Option 2

CC and CVD are subject to the controls described in Option 1. OTVD must be fitted with a cover and a refrigerated freeboard chiller to control emissions from vaporization.

Option 3

CC and CVD are subject to the controls described in Option 1. OTVD must be fitted with a cover and carbon adsorber.

The above regulatory options reflect the range of controls considered by EPA for cold cleaners and open top vapor degreasers. Though two types of control, chillers and carbon adsorbers, are possible control options for conveyorized vapor degreasers, because of resource constraints only carbon adsorbers are considered here. The costs associated with carbon adsorbers are greater than those associated with chillers and consequently any economic impacts resulting from controls requiring chillers will be less adverse than the impacts of controls requiring carbon adsorbers for CVD.

It should also be noted that the control option recommended as the New Source Performance Standard in chapter nine is a combination of options 1 and 2. All OTVD with a surface area greater than one meter square must be fitted with a refrigerated freeboard chiller or a carbon adsorber. For the smaller OTVD only a cover and increased freeboard ratio are necessary. As the distribution of OTVD by size is unknown, it was not possible to evaluate the selected option. It is, however, possible to say that its impact will lie between those estimated for options 1 and 2.

The economic impacts of each regulatory control option are investigated in the context of the following price setting models; (1) full-cost pricing and (2) full-cost absorption. The full-cost pricing model assumes that all cost changes are passed forward to consumers by affected firms in such a way as to maintain existing profit margins and that, because market prices are determined by marginal costs, in each industry all firms will adjust their prices in a similar way. The full-cost absorption model assumes that affected firms absorb all costs, holding prices constant and allowing profit margins to vary. The full-cost pricing model allows for maximum possible price changes and related economic impacts while the full-cost absorption model implies that minimum price changes and economic impacts occur. Johnston[46] and Bain[47] have provided evidence that the market conditions for full-cost pricing exist in many manufacturing industries.* However, in some (though not all) of the affected industries market structures are not compatible with those assumptions. Consequently, it is useful to examine the impacts of the control options under both sets of market conditions as, taken togther, they provide a measure of the widest possible range of economic effects that could be associated with each control option.

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*The necessary market condition for full-cost pricing is that industries should experience constant costs, i.e., unit costs of production should be constant over all probable output levels.

Combining the three regulatory control options with the two price setting models yields the following six scenarios:

Scenario 1: Option 1 + full-cost pricing
Scenario 2: Option 2 + full-cost pricing
Scenario 3: Option 3 + full-cost pricing
Scenario 4: Option 1 + full-cost absorption
Scenario 5: Option 2 + full-cost absorption
Scenario 6: Option 3 + full-cost absorption

The impact analysis for each of the above scenarios focuses on the thirty-five 3-digit SIC code manufacturing industries and the 2-digit SIC code manufacturing industries identified as degreaser users in section 8.1. It also includes the three transport and service industries (SIC's 401, 458, and 753) involved in organic solvent degreasing.

8.4.2 Economic Impact Methodology

8.4.2.1 Estimation Procedures

The economic impact analysis is designed to provide information on the effect of each of the three regulatory control options on five major categories of economic variables:

1. Output and employment.
2. Production cost and price changes within affected industries.
3. Indirect effects on the general level of prices in the economy.
4. Capital financing.
5. Demand for solvent and for degreasing equipment.

All of these categories will be discussed in the context of scenarios 1-3. Under scenarios 4-6 there are, by assumption, no price changes and therefore no direct employment and output changes in industries using degreasers. Under these conditions NSPS's will affect only profitability levels, solvent use, and capital expenditures on degreasing equipment. In scenarios 4-6 the impact analysis is therefore restricted to those three variables.

The impact analysis for each control option is couched within the framework of a "Leontief" fixed coefficient production function* for each affected industry whose parameters are based on 1976 production[48] data. Such production functions imply that given percentage increases in output can only be achieved if the use of all inputs is increased in the same proportions as output. It is assumed that the number of degreasers needed per unit of output is unaffected by the regulatory control options. However, the control options imply that more equipment and energy, and less solvent will be used with new and retrofitted degreasers. Consequently, unit production costs and capital, energy and solvent inputs change as a result of each control. Given full-cost pricing behavior, price changes will result from production cost changes, generating changes in the demand for affected products and consequent adjustments to industry output levels. The output changes are estimated by the procedures described below and used to calculate the total impacts of the control options on employment, capital requirements and the use of degreasers. No such price and output changes occur under full-cost absorption.

1. Output and Employment Effects. None of the options under consideration has a direct impact on the manpower required in typical degreasing operations.† Thus, any impact on employment levels in a solvent degreasing industry can only occur indirectly in response to a change

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*For a detailed discussion of Leontief production functions see Intrilligator.[49]

†Standard operator training and solvent reporting requirements would not impose a measurable burden on workers.

in the demand for the industry's product caused by a price change, itself a consequence of the control options. It is therefore necessary to calculate output effects prior to estimating employment impacts. Any control option-related cost change will, under full-cost pricing, generate an equivalent price change. The price change moves consumers along their demand curves for the affected product, altering the quantity purchased and, consequently, the level of industry output. The change in output is estimated using the following formula:

$$\begin{array}{c}\text{Industry}\\ \text{Output}\\ \text{Change}\end{array} = \left[\begin{array}{c}\text{Estimated}\\ \text{percent change}\\ \text{in price}\end{array}\right] \times \left[\begin{array}{c}\text{Elasticity of}\\ \text{demand for}\\ \text{industry product}\end{array}\right] \times \left[\begin{array}{c}\text{Pre-standard}\\ \text{industry}\\ \text{output level}\end{array}\right]$$

In order to calculate actual output changes, estimates of percent changes in industry prices were based on percent cost changes obtained from the cost data presented in section 8.2. The price elasticities of demand in manufacturing and service industries used in this study were based on estimates presented by Kohn.[50] Pre-control industry output levels were obtained from the Annual Survey of Manufactures.[51]

The changes in manpower requirements associated with estimated output changes were calculated on the basis of a fixed input-output relationship. The fixed input-output coefficient assumption implies that in each industry the man-hours required to produce one unit of output remain constant over all output levels. Consequently, employment impacts in each industry may be calculated by multiplying the manpower required per unit of output, the labor input-output coefficient, by the estimated change in total output. The required industry labor input-output coefficients were obtained by dividing 1976 total industry employment[52] levels by 1976 total values of industry outputs.

2. Production Cost and Price Changes within Affected Industries. In scenarios 1-3 direct price impacts were determined on a SIC-by-SIC basis by assuming that the affected industries would pass on price increases in proportion to the control-related cost increases. The industry-by-industry production cost increases faced by affected firms associated with each control option were estimated in the following way. Total production costs were assumed to be equal to total values of shipments, all profits being regarded as normal profits.* For each industry, the proportional change in production costs caused by the control option is thus the absolute change in production costs associated with the control option divided by the initial level of value of shipments. Changes in production costs were calculated by SIC code industry for each option on the basis of data presented in section 8.2 and information supplied by industry sources (see section 8.4.3). These estimates were used to compute the percentage cost and price changes caused by the control options associated with scenarios 1, 2, and 3. As was noted above, in scenarios 4, 5, and 6 firms are assumed to hold prices constant, fully absorbing all cost changes.

3. Indirect Price Effects. The indirect price impacts associated with scenarios 1, 2, and 3 were calculated through the use of the 1967 input-output model.[53] Price changes for the 39 SIC's were adjusted to correspond to the industry groupings in the 1967 input-output table. The price changes were then fed into the input-output price model, which transformed them into indirect changes for 477 categories of personal consumption expenditure (PCE) items. These price changes were then used to

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*Normal profit is defined as a cost of production in economic theory as it represents the payments which must be provided to the owners of the firm for the services they supply.

calculate a weighted average consumer price index (CPI) price change. It should be noted that, though the structure of American industry has changed since 1967, the 1967 input-output model on which the estimates of induced price effects are based is the most up-to-date model currently available for this purpose.[54]

4. Capital Financing. Generally a firm affected by the control regulations will seek to finance the increased capital expenditures associated with those controls from internal sources of funds because internal funds are cheaper than external funds. External funds, obtained from banks or the sale of bonds and stocks, involve transaction costs, risk premiums and underwriting costs not incurred when equipment purchases are funded out of profits. Consequently, to the extent that firms are forced to seek external funds for control-related equipment, so the financing costs they face will be increased. One measure of the financial burden facing firms is therefore the ratio of control-related capital requirements to normal profits. As this ratio increases firms are likely to have more difficulty in using internal funds to finance control equipment and therefore are likely to experience higher control related cost changes. Increased capital requirements may also disrupt existing investment programs. An indicator of the extent to which this may happen is the ratio of control-related capital requirements to current investment levels. Again, as the value of this ratio increases so does the burden of the controls on the existing investment plans of affected firms.

Empirical measures of the above ratios may be obtained as follows. For each industry the control costs associated with each degreaser are multiplied by the numbers of each type of degreaser in use in the industry and summed. The resulting industry aggregate control costs are first divided by total industry profits and then by total industry investment to obtain the two ratios. The ratios of control equipment expenditures to industry profits and investment costs thus obtained indicate the impact of the control options on typical plants which have to acquire new degreasers for replacement or expansion purposes.

5. The Demand for Degreasing Equipment and Solvent. The firms likely to be most affected by regulatory controls are producers of degreasing equipment and solvent. Each of the control options requires firms to increase their capital expenditures on each new degreaser but leaves unaffected the number of degreasers required per unit of industry output. On the other hand, as industry outputs change, the absolute numbers of degreasers used by firms will change. The impact of different control scenarios on the number of degreasers used by firms is based upon the data presented in Table 8-3 which presents estimates of the numbers of each type of degreaser used per million dollars of output for each industry, i.e., the degreaser input-output coefficients. The change in total numbers of each type of degreasing unit by industry was calculated by multiplying degreaser input-output coefficients by estimated changes in industry outputs.

Difficulties associated with estimating the average level of emissions reductions per degreaser achieved under each of the control options make it impossible to provide meaningful quantitative estimates of reductions in solvent emissions and solvent use. Consequently, a qualitative discussion of the impact of the control options is provided in section 8.4.4.

8.4.2.2 Limitations of the Analysis

Two key assumptions are adopted in the estimation of the economic impacts associated with each control option. First, in each industry firms are assumed to follow a common pricing policy, changing prices in proportion to cost changes under full-cost pricing and holding prices constant in the face of full-cost absorption. The adoption of the above assumption limits the analysis in the following way: only the maximum (full-cost pricing) and minimum (full-cost absorption) possible economic impacts are estimated, providing a measure of the range within which the economic impacts are likely to fall. It was not possible to investigate in detail pricing behavior in each of the 39 industries to obtain a greater degree of precision in the estimation of control-related economic effects. Second, all firms in all industries are assumed to utilize identical degreasing operations. In fact, a wide variety of degreasing operations are utilized by firms within a given industry as well as across industries[55] though it was not possible to identify such variations on the basis of available data. Consequently, to the extent that average types of degreasing operations in each industry differ from the model degreasing operations utilized in this study so the estimated industry economic impacts will be imprecise.

In conclusion, it should also be noted that the data used to estimate numbers of degreasers in each industry is not entirely reliable, though it is the best data available. (See section 8.1.2 (f) and Appendix F). Consequently, economic impacts are overestimated (underestimated) in industries where numbers of degreasers are overestimated (underestimated).

8.4.3 Costs of Regulatory Control Options

Total annualized costs of controls for each type of degreaser were developed in section 8.2. These estimates, properly deflated to 1976 prices for consistency, form the bases for the calculation of total industry control costs associated with each of the three regulatory control options and are presented in Table 8-17 on a before- and after-tax basis.*

8.4.4 Economic Impacts

8.4.4.1 Output and Employment Effects.

Only in the case of the full-cost pricing scenarios (scenarios 1-3) will any output effects occur. Under the full-cost absorption scenarios (scenarios 4-6) there are no price changes and therefore no changes in demand, output and employment. Estimates of the output and employment effects associated with scenarios 1-3 are presented in Table 8-18 together with the price elasticities of demand and percentage price changes on which they are based. Four major output implications can be identified.

1. Under each of the three control options, given full-cost pricing behavior by firms, the aggregate output of the economy will increase.
2. Under control options 1 and 2 output levels in each of the thirty-nine affected industries will rise.
3. Under control option 3 output will fall in eleven of the affected industries and increase in the remaining twenty-eight sectors.
4. The impacts upon industry output levels are relatively small (less than 0.163 percent of pre-regulation production levels for each industry under all scenarios).

The increases in industry and local output levels under scenarios 1 and 2 are caused by the cost reductions that result from the implementation of

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*Assuming equity funding of control equipment and straight line depreciation over the life of the equipment for tax purposes, after tax annualized cost = (1-t) X (before tax annualized costs), where t measures the combined state and federal tax rate on corporate income.

Table 8-17. Annualized Costs of Controls for Typical Degreasers, 1976 Prices*

		Annualized Costs (Dollars)					
		Before Tax			After Tax		
Control Options	Type of Degreaser	Capital Costs	Operating Costs	Total Costs	Capital Costs	Operating Costs	Total Costs
Option 1	CC	10	-110	-100	10	-50	-40
	OTVD	350	-890	-540	160	-380	-220
	CVD	3230	-4830	-1600	1520	-2270	-750
Option 2	CC	10	-110	-100	10	-50	-40
	OTVD	1000	-1380	-380	470	-650	-180
	CVD	3230	-4830	-1600	1520	-2270	-750
Option 3	CC	10	-110	-100	10	-50	-40
	OTVD	2870	-1490	1380	1350	-700	650
	CVD	3230	-4830	-1600	1520	-2270	-750

*Source: Section 8.2.

Table 8-18. Output Effects, Scenarios 1-3.

SIC	Industry Short Title	1976 Output in Millions of Dollars	Elasticity of Demand	Scenario 1 Percent Change in Price	Scenario 1 Percent Change in Output	Scenario 1 Absolute Change in Output in Millions of Dollars	Scenario 2 Percent Change in Price	Scenario 2 Percent Change in Output	Scenario 2 Absolute Change in Output in Millions of Dollars	Scenario 3 Percent Change in Price	Scenario 3 Percent Change in Output	Scenario 3 Absolute Change in Output in Millions of Dollars
39	Miscellaneous Industry	16286.0	-1.000	-0.006	0.006	0.943	-0.006	0.006	0.902	-0.002	0.002	0.393
254	Partitions and Fixtures	1952.3	-1.000	-0.023	0.023	0.458	-0.022	0.022	0.435	-0.007	0.007	0.144
259	Misc. Furniture and Fixtures	1044.1	-1.000	-0.020	0.020	0.205	-0.019	0.019	0.198	-0.010	0.010	0.107
332	Iron and Steel Foundries	9787.0	-1.000	-0.002	0.002	0.151	-0.001	0.001	0.142	-0.000	0.000	0.029
335	Nonferrous Rolling and Drawing	18753.3	-0.500	-0.001	0.001	0.112	-0.001	0.001	0.103	0.000	-0.000	-0.012
336	Nonferrous Foundries	3389.4	-0.500	-0.007	0.003	0.116	-0.007	0.003	0.113	-0.004	0.002	0.069
339	Misc. Primary Metal Products	1235.6	-1.000	-0.080	0.080	0.990	-0.073	0.073	0.906	0.011	-0.011	-0.132
342	Cutlery, Hand Tools, and Hardware	7392.5	-1.000	-0.014	0.014	1.041	-0.013	0.013	0.964	-0.000	0.000	0.011
343	Plumbing and Heating (except Electric)	2608.0	-1.000	-0.008	0.008	0.215	-0.008	0.008	0.201	-0.001	0.001	0.032
344	Fabricated Structural Metal Products	21583.9	-1.000	-0.007	0.007	1.493	-0.007	0.007	1.441	-0.004	0.004	0.803
345	Screw Machine Products, Bolts, etc.	4396.0	-1.000	-0.007	0.007	0.319	-0.007	0.007	0.308	-0.004	0.004	0.176
346	Metal Gorgings and Stampings	15249.7	-1.000	-0.002	0.002	0.360	-0.002	0.002	0.347	-0.001	0.001	0.177
347	Metal Services	2877.1	-1.000	-0.047	0.047	1.366	-0.045	0.045	1.291	-0.013	0.013	0.360
348	Ordnance and Accessories	2804.3	-1.000	-0.000	0.000	0.008	-0.000	0.000	0.008	-0.000	0.000	0.004
349	Misc. Fabricated Metal Products	12612.1	-1.000	-0.009	0.009	1.109	-0.008	0.008	1.052	-0.003	0.003	0.337
351	Engines and Turbines	9009.1	-1.000	-0.001	0.001	0.049	-0.001	0.001	0.047	-0.000	0.000	0.020
352	Farm and Garden Machinery	10533.7	-1.000	-0.005	0.005	0.504	-0.005	0.005	0.484	-0.002	.0.002	0.233
353	Construction and Related Machinery	19740.8	-1.000	-0.004	0.004	0.696	-0.003	0.003	0.666	-0.001	0.001	0.292
354	Metalworking Machinery	11278.2	-1.000	-0.018	0.018	1.998	-0.017	0.017	1.960	-0.013	0.013	1.489
355	Special Industrial Machinery	9453.5	-1.000	-0.005	0.005	0.502	-0.005	0.005	0.499	-0.005	0.005	0.465
356	General Industrial Machinery	14196.5	-1.000	-0.015	0.015	2.182	-0.014	0.014	2.057	-0.004	0.004	0.504
357	Office and Computing Machines	13722.8	-1.000	-0.002	0.002	0.301	-0.002	0.002	0.287	-0.001	0.001	0.105
358	Refrigeration and Service Machinery	10660.2	-1.000	-0.003	0.003	0.349	-0.003	0.003	0.338	-0.002	0.002	0.198
359	Misc. Machinery, except Electrical	6930.5	-1.000	-0.060	0.060	4.125	-0.058	0.058	4.053	-0.046	0.046	3.154
361	Electric Distributing Equipment	4688.0	-1.000	-0.010	0.010	0.481	-0.009	0.009	0.423	0.006	-0.006	-0.298
362	Electrical Industrial Apparatus	8452.9	-1.000	-0.003	0.003	0.287	-0.003	0.003	0.268	-0.000	0.000	0.037
364	Electric Lighting and Wiring Equip.	7342.0	-1.000	-0.018	0.018	1.349	-0.016	0.016	1.185	0.012	-0.012	-0.856
366	Communication Equipment	19138.0	-1.000	-0.007	0.007	1.392	-0.006	0.006	1.223	0.005	-0.005	-0.879
367	Electronic Components and Accessories	12433.0	-1.000	-0.008	0.008	0.937	-0.007	0.007	0.847	0.002	-0.002	-0.281
369	Misc. Electrical Equip. and Supplies	6829.0	-1.000	-0.004	0.004	0.256	-0.004	0.004	0.251	-0.003	0.003	0.193
371	Motor Vehicles and Equipment	95381.0	-1.000	-0.001	0.001	0.727	-0.001	0.001	0.685	-0.000	0.000	0.164
372	Aircraft and Parts	23463.0	-1.000	-0.006	0.006	1.525	-0.006	0.006	1.340	0.004	-0.004	-0.961
376	Guided Missiles, Space Vehicles, Parts	7142.0	-1.000	-0.001	0.001	0.095	-0.001	0.001	0.083	0.001	-0.001	-0.064
379	Misc. Transportation Equipment	3117.0	-1.000	-0.006	0.006	0.202	-0.006	0.006	0.202	-0.006	0.006	0.202
381	Engineering and Scientific Instruments	1847.0	-1.000	-0.024	0.024	0.440	-0.022	0.022	0.403	0.003	-0.003	-0.052
382	Measuring and Controlling Devices	6180.0	-1.000	-0.028	0.028	1.742	-0.025	0.025	1.529	0.018	-0.018	-1.116
401	Railroads - Maintenance	18536.0	-1.000	-0.000	0.000	0.069	-0.000	0.000	0.065	-0.000	0.000	0.014
458	Air Transport - Maintenance	3701.0	-1.000	-0.067	0.067	2.473	-0.061	0.061	2.255	0.012	-0.012	-0.460
753	Auto Repair	13269.0	-0.400	-0.164	0.065	8.678	-0.164	0.065	8.678	-0.164	0.065	8.678
		459014.4				40.247			38.241	-0.006	0.003	13.277

Source: Referenc~~es~~ 5 and 50.

the control technologies. The cost reductions themselves may be explained by the fact that the value of the solvent savings firms can achieve by utilizing the control equipment associated with options 1 and 2 exceed the annualized capital costs of the machinery.

Under control option 3 the costs associated with cold cleaning and conveyorized degreasing fall but annualized costs associated with open top vapor degreasing rise. In eleven industries where relatively large amounts of degreasing are carried out with OTVD's* the cost increases associated with the OTVD controls outweigh the cost decreases associated with CC and CVD controls. The result is a net increase in production costs and prices, and a decline in industry outputs. In the remaining twenty-eight industries the cost increases associated with OTVD's were more than offset by the cost decreases associated with CC's and CVD's, resulting in net cost reductions, price decreases and output increases in those industries. Under option 3 the net impact upon aggregate output is positive as the total fall in output in the eleven cost-increasing industries is smaller than the total increase in output in the remaining twenty-eight cost-decreasing industries.

The percent output changes are small for all industries under all scenarios because the percent changes in production costs and prices resulting from the control options are small. This is a consequence of the fact that solvent metal degreasing is only a tiny part of the total production process in most industries (see section 8.1.2).

Output effects are largest under scenario 1, become smaller under scenario 2 and are smallest under scenario 3 because the size of cost and price reductions fall (and under option 3 become cost and price increases in eleven industries) as the control equipment requirements for OTVD's are expanded from an increased freeboard ratio to a freeboard chiller and, finally, a carbon adsorber. Though the percent changes in output levels are small under all control options, the aggregate absolute changes are quite large: $40.25 millions under scenario 1, $38.24 millions under scenario 2, and $13.28 millions under scenario 3. In the cases of scenarios 1 and 2 moderate output increases (over $1 million) occurred in SIC code industries 342 (cutlery and hand tools), 344 (fabricated metal products), 347 (metal services), 354 (metal working machinery), 356 (general industrial machinery), 364 (electrical lighting and wiring equipment), 366 (communications equipment), 458 (air transport and maintenance) and 753 (auto repairs). Under scenario 3 moderate output increases occurred only in SIC's 354, 359, and 753. Three industries using relatively large numbers of OTVD's which experienced moderate output increases under sceanrios 1 and 2, experienced ouput decreases under scenario 3. These were SIC's 364, 366, and 458.

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*These eleven industries, by 3-digit SIC code, are 335, 339, 361, 364, 366, 367, 372, 376, 381, 382, 458.

None of the control options considered here increase the amount of manpower required to operate degreasing equipment. Consequently the only employment impacts that occur are those caused by control induced output changes. Such output changes are zero under scenarios 4-6 and therefore the associated employment impacts are also zero. Under scenarios 1-3 price and output changes occur as a result of the full-cost pricing behavior attributed to firms. Utilizing the labor input-output coefficients presented in column 4 of Table 8-19, changes in manpower requirements were estimated for each industry under each scenario. Under scenarios 1 and 2, for all industries other than SIC 753 (where 99 jobs are created) the employment impacts,

Table 8-19. Additional Employment Requirements, Scenarios 1-3.

					Scenario 1		Scenario 2		Scenario 3	
	Col. 1	Col. 2 Pre-Standard Output in Millions of Dollars	Col. 3 Pre-Standard Employment in Man Years	Col. 4 Labor-Capital Ratio [Col. 2/Col. 3]	Col. 5 Change in Output in Millions of Dollars	Col. 6 Change in Employment in Man Years [Col. 4 x Col. 5]	Col. 7 Change in Output in Millions of Dollars	Col. 8 Change in Employment in Man Years [Col. 4 x Col. 7]	Col. 9 Change in Output in Millions of Dollars	Col. 10 Change in Employment in Man Years [Col. 4 x Col. 9]
SIC	Industry Short Title									
39	Miscellaneous Industry	16286.0	410000	25.2	0.943	24	0.902	23	0.393	10
254	Partitions and Fixtures	1952.3	50900	26.1	0.458	12	0.435	11	0.144	4
259	Misc. Furniture and Fixtures	1044.1	26100	25.0	0.205	5	0.198	5	0.107	3
332	Iron and Steel Foundries	9787.0	216400	22.1	0.151	3	0.142	3	0.029	1
335	Nonferrous Rolling and Drawing	18753.3	171300	9.1	0.112	1	0.103	1	-0.012	-0
336	Nonferrous Foundries	3389.4	84700	25.0	0.116	3	0.113	3	0.069	2
339	Misc. Primary Metal Products	1235.6	24600	19.9	0.990	20	0.906	18	-0.132	-3
342	Cutlery, Hand Tools, and Hardware	7392.5	158400	21.4	1.041	22	0.964	21	0.011	0
343	Plumbing and Heating (except Electric)	2608.0	50600	19.4	0.215	4	0.201	4	0.032	1
344	Fabricated Structural Metal Products	21583.9	401400	18.6	1.493	28	1.441	27	0.803	15
345	Screw Machine Products, Bolts, etc.	4396.0	99600	22.7	0.319	7	0.308	7	0.176	4
346	Metal Gorgings and Stampings	15249.7	265400	17.4	0.360	6	0.347	6	0.177	3
347	Metal Services	2877.1	89800	31.2	1.366	43	1.291	40	0.360	11
348	Ordnance and Accessories	2804.3	74700	26.6	0.008	0	0.008	0	0.004	0
349	Misc. Fabricated Metal Products	12612.1	259200	20.6	1.109	23	1.052	22	0.337	7
351	Engines and Turbines	9009.1	124600	13.8	0.049	1	0.047	1	0.020	0
352	Farm and Garden Machinery	10533.7	14600	1.4	0.504	1	0.484	1	0.233	0
353	Construction and Related Machinery	19740.8	311500	15.8	0.696	11	0.666	11	0.292	5
354	Metalworking Machinery	11278.2	289500	25.7	1.998	51	1.960	50	1.489	38
355	Special Industrial Machinery	9453.5	196200	20.8	0.502	10	0.499	10	0.465	10
356	General Industrial Machinery	14196.5	280700	19.8	2.182	43	2.057	41	0.504	10
357	Office and Computing Machines	13722.8	229400	16.7	0.301	5	0.287	5	0.105	2
358	Refrigeration and Service Machinery	10660.2	172900	16.2	0.349	6	0.338	5	0.198	3
359	Misc. Machinery, except Electrical	6930.5	20900	3.0	4.125	12	4.053	12	3.154	10
361	Electric Distributing Equipment	4680.0	104100	22.1	0.481	11	0.423	9	-0.298	-7
362	Electrical Industrial Apparatus	8452.9	194700	23.0	0.287	7	0.268	6	0.037	1
364	Electric Lighting and Wiring Equip.	7342.0	159700	21.8	1.349	29	1.185	26	-0.856	-19
366	Communication Equipment	19138.0	421500	22.0	1.392	31	1.223	27	-0.879	-19
367	Electronic Components and Accessories	12433.0	323000	26.0	0.937	24	0.847	22	-0.281	-7
369	Misc. Electrical Equip. and Supplies	6829.0	129600	19.0	0.256	5	0.251	5	0.193	4
371	Motor Vehicles and Equipment	95301.0	297100	3.1	0.727	2	0.685	2	0.164	1
372	Aircraft and Parts	23463.0	408000	17.4	1.525	27	1.340	23	-0.961	-17
376	Guided Missiles, Space Vehicles, Parts	7142.0	141700	19.8	0.095	2	0.083	2	-0.064	-1
379	Misc. Transportation Equipment	3117.0	49700	15.9	0.202	3	0.202	3	0.202	3
381	Engineering and Scientific Instruments	1847.0	43500	23.6	0.440	10	0.403	9	-0.052	-1
382	Measuring and Controlling Devices	6180.0	168900	27.3	1.742	48	1.529	42	-1.116	-30
401	Railroads - Maintenance	18536.0	496500	26.8	0.069	2	0.065	2	0.014	0
458	Air Transport - Maintenance	3701.0	51100	13.8	2.473	34	2.255	31	-0.460	-6
753	Auto Repair	13269.0	763000	57.5	8.678	499	8.678	499	8.678	499
		459014.4	7775500		40.247	1075	38.241	1035	13.277	534

Source: References 5-52.

though positive, are extremely small. The aggregate effect is more substantial. Under scenario 1 (control option 1) a total of 1,075 jobs are created and under scenario 2 (control option 2) that total is 1,035. If control option 3 were to be introduced the number of new jobs would fall to 534, with some industries experiencing small decreases in employment. Only in one industry (SIC 381) would more than 25 jobs be lost.

It should be emphasized that, as noted in section 8.4.2, the output and employment impacts based on a full-cost pricing model are maximum estimates and probably overstate the effects of the control options. On the other hand it is unlikely that the full-cost absorption scenarios which imply zero output and employment effects in all industries are more realistic. As pointed out above, empirical evidence and economic theory suggest that firms do adjust prices in some way in response to cost changes.

8.4.4.2 Production Cost and Price Changes in Affected Industries.

The after tax costs of complying with scenarios 1 and 4 (control option 1), scenarios 2 and 5 (control option 2) and scenarios 3 and 6 (control option 3) are presented in Tables 8-20A, B, and C respectively. In each scenario for each industry the installed capital cost of control equipment and its associated annual capital charge are positive. Annual operating costs are negative, i.e., annual reductions in firms expenditures on solvents resulting from the controls more than offset increases in expenditures on energy and other variable inputs used in degreasing. Under scenarios 1, 2, 4, and 5 (control options 1 and 2) annual operating costs in all industries fall by a larger amount than annual capital charges rise. Changes in annualized total costs are consequently negative. Under scenarios 3 and 6 (control option 3) in industries where OTVD's are used relatively intensively compared to CC's and CVD's annual operating costs fall by a smaller

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Table 8-20A. Total Compliance Costs: Scenarios 1 and 4.

SIC	Industry Short Title	Installed Capital Cost ($ millions)	Annual Capital Charge ($ millions)	Operating Costs ($ millions)	Total Annualized Cost ($ millions)	Total Annualized Cost as a Percent of Projected 1978 Output (Percent)
39	Miscellaneous Industry	1.465	0.310	-1.253	-0.943	-0.006
254	Partitions and Fixtures	1.294	0.274	-0.732	-0.458	-0.023
259	Misc. Furniture and Fixtures	0.439	0.093	-0.298	-0.205	-0.020
332	Iron and Steel Foundries	0.409	0.087	-0.238	-0.151	-0.002
335	Nonferrous Rolling and Drawing	0.785	0.166	-0.390	-0.224	-0.001
336	Nonferrous Foundries	0.379	0.080	-0.313	-0.232	-0.007
339	Misc. Primary Metal Products	3.511	0.742	-1.732	-0.990	-0.080
342	Cutlery, Hand Tools, and Hardware	3.257	0.689	-1.730	-1.041	-0.014
343	Plumbing and Heating (except Electric)	0.593	0.125	-0.340	-0.215	-0.008
344	Fabricated Structural Metal Products	2.675	0.566	-2.058	-1.493	-0.007
345	Screw Machine Products, Bolts, etc.	0.562	0.119	-0.438	-0.319	-0.007
346	Metal Gorgings and Stampings	0.690	0.146	-0.506	-0.360	-0.002
347	Metal Services	3.396	0.718	-2.084	-1.366	-0.047
348	Ordnance and Accessories	0.015	0.003	-0.011	-0.008	-0.000
349	Misc. Fabricated Metal Products	2.642	0.559	-1.668	-1.109	-0.009
351	Engines and Turbines	0.092	0.019	-0.069	-0.049	-0.001
352	Farm and Garden Machinery	0.943	0.200	-0.704	-0.504	-0.005
353	Construction and Related Machinery	1.364	0.288	-0.984	-0.696	-0.004
354	Metalworking Machinery	2.428	0.513	-2.512	-1.998	-0.018
355	Special Industrial Machinery	0.400	0.085	-0.587	-0.502	-0.005
356	General Industrial Machinery	5.245	1.109	-3.291	-2.182	-0.015
357	Office and Computing Machines	0.643	0.136	-0.437	-0.301	-0.002
358	Refrigeration and Service Machinery	0.560	0.118	-0.468	-0.349	-0.003
359	Misc. Machinery, except Electrical	4.822	1.020	-5.145	-4.125	-0.060
361	Electric Distributing Equipment	1.620	0.343	-0.823	-0.481	-0.010
362	Electrical Industrial Apparatus	0.596	0.126	-0.413	-0.287	-0.003
364	Electric Lighting and Wiring Equip.	4.567	0.966	-2.315	-1.349	-0.018
366	Communication Equipment	4.701	0.994	-2.387	-1.392	-0.007
367	Electronic Components and Accessories	2.636	0.558	-1.495	-0.937	-0.008
369	Misc. Electrical Equip. and Supplies	0.272	0.058	-0.314	-0.256	-0.004
371	Motor Vehicles and Equipment	1.448	0.306	-1.033	-0.727	-0.001
372	Aircraft and Parts	5.338	1.129	-2.654	-1.525	-0.006
376	Guided Missiles, Space Vehicles, Parts	0.339	0.072	-0.167	-0.095	-0.001
379	Misc. Transportation Equipment	0.126	0.027	-0.229	-0.202	-0.006
381	Engineering and Scientific Instruments	0.834	0.176	-0.616	-0.440	-0.024
382	Measuring and Controlling Devices	4.346	0.919	-2.661	-1.742	-0.028
401	Railroads - Maintenance	0.081	0.017	-0.086	-0.069	-0.000
458	Air Transport - Maintenance	3.598	0.761	-3.234	-2.473	-0.067
753	Auto Repair	13.577	2.871	-24.567	-21.695	-0.164
		62.685	17.486	-70.978	-53.492	-0.012

Source: Reference 5; Table 8-17.

Table 8-20B. Total Compliance Costs: Scenarios 2 and 5.

SIC	Industry Short Title	Installed Capital Cost ($ millions)	Annual Capital Charge ($ millions)	Operating Costs ($ millions)	Total Annualized Cost ($ millions)	Total Annualized Cost as a Percent of Projected 1978 Output (Percent)
39	Miscellaneous Industry	2.353	0.498	-1.399	-0.902	-0.006
254	Partitions and Fixtures	1.801	0.381	-0.816	-0.435	-0.022
259	Misc. Furniture and Fixtures	0.596	0.126	-0.324	-0.198	-0.019
332	Iron and Steel Foundries	0.607	0.128	-0.270	-0.142	-0.001
335	Nonferrous Rolling and Drawing	1.185	0.251	-0.456	-0.205	-0.001
336	Nonferrous Foundries	0.531	0.112	-0.338	-0.225	-0.007
339	Misc. Primary Metal Products	5.323	1.126	-2.032	-0.906	-0.073
342	Cutlery, Hand Tools, and Hardware	4.922	1.041	-2.005	-0.964	-0.013
343	Plumbing and Heating (except Electric)	0.889	0.188	-0.389	-0.201	-0.008
344	Fabricated Structural Metal Products	3.790	0.801	-2.243	-1.441	-0.007
345	Screw Machine Products, Bolts, etc.	0.793	0.168	-0.476	-0.308	-0.007
346	Metal Gorgings and Stampings	0.987	0.209	-0.555	-0.347	-0.002
347	Metal Services	5.020	1.062	-2.353	-1.291	-0.045
348	Ordnance and Accessories	0.022	0.005	-0.012	-0.008	-0.000
349	Misc. Fabricated Metal Products	3.891	0.823	-1.875	-1.052	-0.008
351	Engines and Turbines	0.140	0.030	-0.077	-0.047	-0.001
352	Farm and Garden Machinery	1.383	0.292	-0.777	-0.484	-0.005
353	Construction and Related Machinery	2.016	0.426	-1.092	-0.666	-0.003
354	Metalworking Machinery	3.250	0.687	-2.648	-1.960	-0.017
355	Special Industrial Machinery	0.460	0.097	-0.596	-0.499	-0.005
356	General Industrial Machinery	7.957	1.683	-3.740	-2.057	-0.014
357	Office and Computing Machines	0.961	0.203	-0.490	-0.287	-0.002
358	Refrigeration and Service Machinery	0.804	0.170	-0.508	-0.338	-0.003
359	Misc. Machinery, except Electrical	6.390	1.351	-5.404	-4.053	-0.058
361	Electric Distributing Equipment	2.879	0.609	-1.032	-0.423	-0.009
362	Electrical Industrial Apparatus	0.999	0.211	-0.479	-0.268	-0.003
364	Electric Lighting and Wiring Equip.	8.130	1.719	-2.904	-1.185	-0.016
366	Communication Equipment	8.371	1.770	-2.994	-1.223	-0.006
367	Electronic Components and Accessories	4.605	0.974	-1.820	-0.847	-0.007
369	Misc. Electrical Equip. and Supplies	0.375	0.079	-0.331	-0.251	-0.004
371	Motor Vehicles and Equipment	2.359	0.499	-1.184	-0.685	-0.001
372	Aircraft and Parts	9.355	1.978	-3.318	-1.340	-0.006
376	Guided Missiles, Space Vehicles, Parts	0.596	0.126	-0.209	-0.083	-0.001
379	Misc. Transportation Equipment	0.126	0.027	-0.229	-0.202	-0.006
381	Engineering and Scientific Instruments	1.630	0.345	-0.748	-0.403	-0.022
382	Measuring and Controlling Devices	8.962	1.895	-3.424	-1.529	-0.025
401	Railroads - Maintenance	0.169	0.036	-0.100	-0.065	-0.000
458	Air Transport - Maintenance	8.337	1.763	-4.018	-2.255	-0.061
753	Auto Repair	13.577	2.871	-24.567	-21.695	-0.168
		126.540	26.760	-78.233	-51.473	-0.011

Source: Reference 5; Table 8-17.

Table 8-20C. Total Compliance Costs: Scenarios 3 and 6.

SIC	Industry Short Title	Installed Capital Cost ($ millions)	Annual Capital Charge ($ millions)	Operating Costs ($ millions)	Total Annualized Cost ($ millions)	Total Annualized Cost as a Percent of Projected 1978 Output (Percent)
39	Miscellaneous Industry	4.918	1.040	-1.433	-0.393	-0.002
254	Partitions and Fixtures	3.268	0.691	-0.835	-0.144	-0.007
259	Misc. Furniture and Fixtures	1.052	0.222	-0.330	-0.107	-0.010
332	Iron and Steel Foundries	1.179	0.249	-0.278	-0.029	-0.000
335	Nonferrous Rolling and Drawing	2.342	0.495	-0.471	0.024	0.000
336	Nonferrous Foundries	0.970	0.205	-0.344	-0.138	-0.004
339	Misc. Primary Metal Products	10.562	2.234	-2.102	0.132	0.011
342	Cutlery, Hand Tools, and Hardware	9.735	2.059	-2.069	-0.011	-0.000
343	Plumbing and Heating (except Electric)	1.745	0.369	-0.401	-0.032	-0.001
344	Fabricated Structural Metal Products	7.010	1.483	-2.285	-0.803	-0.004
345	Screw Machine Products, Bolts, etc.	1.462	0.309	-0.485	-0.176	-0.004
346	Metal Gorgings and Stampings	1.843	0.390	-0.567	-0.177	-0.001
347	Metal Services	9.716	2.055	-2.415	-0.360	-0.013
348	Ordnance and Accessories	0.043	0.009	-0.013	-0.004	-0.000
349	Misc. Fabricated Metal Products	7.500	1.586	-1.923	-0.337	-0.003
351	Engines and Turbines	0.277	0.059	-0.078	-0.020	-0.000
352	Farm and Garden Machinery	2.653	0.561	-0.794	-0.233	-0.002
353	Construction and Related Machinery	3.900	0.825	-1.117	-0.292	-0.001
354	Metalworking Machinery	5.627	1.190	-2.679	-1.489	-0.013
355	Special Industrial Machinery	0.631	0.133	-0.599	-0.465	-0.005
356	General Industrial Machinery	15.794	3.340	-3.844	-0.504	-0.004
357	Office and Computing Machines	1.880	0.398	-0.502	-0.105	-0.001
358	Refrigeration and Service Machinery	1.510	0.319	-0.518	-0.198	-0.002
359	Misc. Machinery, except Electrical	10.923	2.310	-5.464	-3.154	-0.046
361	Electric Distributing Equipment	6.517	1.378	-1.080	0.298	0.006
362	Electrical Industrial Apparatus	2.165	0.458	-0.495	-0.037	-0.000
364	Electric Lighting and Wiring Equip.	18.427	3.897	-3.041	0.856	0.012
366	Communication Equipment	18.977	4.013	-3.134	0.879	0.005
367	Electronic Components and Accessories	10.295	2.177	-1.896	0.281	0.002
369	Misc. Electrical Equip. and Supplies	0.671	0.142	-0.334	-0.193	-0.003
371	Motor Vehicles and Equipment	4.991	1.055	-1.219	-0.164	-0.000
372	Aircraft and Parts	20.964	4.433	-3.472	0.961	0.004
376	Guided Missiles, Space Vehicles, Parts	1.340	0.283	-0.219	0.064	0.001
379	Misc. Transportation Equipment	0.126	0.027	-0.229	-0.202	-0.006
381	Engineering and Scientific Instruments	3.927	0.830	-0.778	0.052	0.003
382	Measuring and Controlling Devices	22.305	4.717	-3.601	1.116	0.018
401	Railroads - Maintenance	0.424	0.090	-0.104	-0.014	-0.000
458	Air Transport - Maintenance	22.035	4.660	-4.200	0.460	0.012
753	Auto Repair	13.577	2.871	-24.567	-21.695	-0.164
		253.280	53.562	-79.914	-26.352	-0.006

Source: Reference 5; Table 8-17.

amount than the increase in annual capital charges associated with the control equipment. Consequently, for those 11 industries total annualized costs rise, though by less than two hundredths of a percentage point of the value of total output in each case. (See Table 8-20.C.)

The percentage changes in costs presented in Table 8-20 equal percentage changes in prices under scenarios 1-3. The relevant price changes are presented in Table 8-21. Prices are assumed to be unaffected by cost changes under the full-cost absorption scenarios.

8.4.4.3 Induced Price Effects.

Using the 1967 input-output model for the U.S. economy the impact upon the general level of prices in the U.S. economy (measured by the implied change in the consumer price index) under scenarios 1 and 2 was estimated to be a 0.015 percent decrease in the CPI. Under scenario 3 the fall in the CPI was estimated to be 0.015 percent. There are no inflationary impacts under scenarios 4-6.

8.4.4.4 Capital Financing.

Each control option requires a substantial increase in the capital costs of degreasing units. However, funding of the necessary capital expenditures does not appear to pose a serious problem for affected firms for two reasons: (1) the relatively small role of degreasing in firms' production processes and (2) the solvent savings achieved by firms using the controls which substantially offset the associated capital costs (see Table 8-17). The size of the impacts of each control option on the capital financing position of firms affected by the controls is evaluated below for both the full-cost pricing and full-cost absorption scenarios. It should be

Table 8-21. Direct Price Effects, Scenarios 1-3.

SIC	Industry Short Title	Scenario 1: Percent Change in Price	Scenario 2: Percent Change in Price	Scenario 3: Percent Change in Price
39	Miscellaneous Industry	-0.0058	-0.0055	-0.0024
254	Partitions and Fixtures	-0.0235	-0.0223	-0.0074
259	Misc. Furniture and Fixtures	-0.0196	-0.0189	-0.0103
332	Iron and Steel Foundries	-0.0015	-0.0015	-0.0003
335	Nonferrous Rolling and Drawing	-0.0012	-0.0011	0.0001
336	Nonferrous Foundries	-0.0069	-0.0066	-0.0041
339	Misc. Primary Metal Products	-0.0801	-0.0734	0.0107
342	Cutlery, Hand Tools, and Hardware	-0.0141	-0.0130	-0.0001
343	Plumbing and Heating (except Electric)	-0.0082	-0.0077	-0.0012
344	Fabricated Structural Metal Products	-0.0069	-0.0067	-0.0037
345	Screw Machine Products, Bolts, etc.	-0.0073	-0.0070	-0.0040
346	Metal Gorgings and Stampings	-0.0024	-0.0023	-0.0012
347	Metal Services	-0.0475	-0.0449	-0.0125
348	Ordnance and Accessories	-0.0003	-0.0003	-0.0001
349	Misc. Fabricated Metal Products	-0.0088	-0.0083	-0.0027
351	Engines and Turbines	-0.0005	-0.0005	-0.0002
352	Farm and Garden Machinery	-0.0048	-0.0046	-0.0022
353	Construction and Related Machinery	-0.0035	-0.0034	-0.0015
354	Metalworking Machinery	-0.0177	-0.0174	-0.0132
355	Special Industrial Machinery	-0.0053	-0.0053	-0.0049
356	General Industrial Machinery	-0.0154	-0.0145	-0.0035
357	Office and Computing Machines	-0.0022	-0.0021	-0.0008
358	Refrigeration and Service Machinery	-0.0033	-0.0032	-0.0019
359	Misc. Machinery, except Electrical	-0.0595	-0.0585	-0.0455
361	Electric Distributing Equipment	-0.0103	-0.0090	0.0064
362	Electrical Industrial Apparatus	-0.0034	-0.0032	-0.0004
364	Electric Lighting and Wiring Equip.	-0.0184	-0.0161	0.0117
366	Communication Equipment	-0.0073	-0.0064	0.0046
367	Electronic Components and Accessories	-0.0075	-0.0068	0.0023
369	Misc. Electrical Equip. and Supplies	-0.0037	-0.0037	-0.0028
371	Motor Vehicles and Equipment	-0.0008	-0.0007	-0.0002
372	Aircraft and Parts	-0.0065	-0.0057	0.0041
376	Guided Missiles, Space Vehicles, Parts	-0.0013	-0.0012	0.0009
379	Misc. Transportation Equipment	-0.0065	-0.0065	-0.0065
381	Engineering and Scientific Instruments	-0.0238	-0.0218	0.0028
382	Measuring and Controlling Devices	-0.0282	-0.0247	0.0181
401	Railroads - Maintenance	-0.0004	-0.0003	-0.0001
458	Air Transport - Maintenance	-0.0668	-0.0609	0.0124
753	Auto Repair	-0.1635	-0.1635	-0.1635

Source: Table 8-20.

noted that the impact of the control options on rates of return on investment for firms adopting the control technology are not examined as it was not possible to identify typical model industrial plants for all of the affected SIC code 3-digit industries. Data on financing is presented in Table 8-22.

(a) Full-Cost Pricing Scenarios (1-3). If full-cost pricing is assumed then product prices will be adjusted in a way which leaves profit rates constant for firms affected by the regulatory controls. Thus, in the analysis of scenarios 1-3 the ratio of total annualized costs to normal profits is of little interest as it indicates the magnitude by which profits change only if, when costs of production change, product prices are held constant. However, the ratio of installed capital cost to normal profit is a matter of concern. As was noted above, the cheapest funds available to a firm for financing new pollution control equipment are internal funds, i.e., its profits. Thus, the ratio of the installed capital cost of new pollution control equipment to normal profits is an indicator of both the likely cost to the firm of financing new equipment and the difficulty it will face in acquiring funds for the investment. As the ratio increases the firm becomes more likely to seek funds from external sources which are more costly and more difficult to tap.

Under scenarios 1 and 2 the ratio of the installed capital cost of pollution controls to normal profits is relatively small. In no case are the additional capital costs more than 6.2 percent of normal profit. Thus affected firms in all industries could be regarded as having little difficulty in funding the purchase of the pollution control equipment recommended under control options 1 and 2. If carbon adsorbers were to be

Table 8-22. Effects of Control Options of Profit Rates, Capital Availability and Investment

				Scenarios 1 and 4			Scenarios 2 and 5			Scenarios 3 and 6		
SIC	Industry Short Title	Profit After Tax as a Percent of Sales	Normal Investment Expenditures ($ millions)	Ratio of Total Annualized Cost to Normal Profit	Ratio of Installed Capital Cost to Normal Profit	Ratio of Installed Capital Cost to Projected Normal Investment	Ratio of Total Annualized Cost to Normal Profit	Ratio of Installed Capital Cost to Normal Profit	Ratio of Installed Capital Cost to Projected Normal Investment	Ratio of Total Annualized Cost to Normal Profit	Ratio of Installed Capital Cost to Normal Profit	Ratio of Installed Capital Cost to Projected Normal Investment
39	Miscellaneous Industry	6.44	560.60	-0.00090	0.00140	0.00261	-0.00086	0.00224	0.00420	-0.00038	0.00469	0.00877
254	Partitions and Fixtures	3.35	30.00	-0.00701	0.01979	0.03405	-0.00665	0.02754	0.04741	-0.00221	0.04996	0.08599
259	Misc. Furniture and Fixtures	3.35	21.70	-0.00586	0.01254	0.02022	-0.00565	0.01705	0.02748	-0.00307	0.03007	0.04846
332	Iron and Steel Foundries	3.64	643.20	-0.00042	0.00115	0.00064	-0.00040	0.00170	0.00094	-0.00008	0.00331	0.00183
335	Nonferrous Rolling and Drawing	3.64	438.60	-0.00033	0.00115	0.00179	-0.00036	0.00174	0.00270	0.00003	0.00343	0.00534
336	Nonferrous Foundries	3.64	114.40	-0.00188	0.00308	0.00332	-0.00183	0.00431	0.00464	-0.00112	0.00786	0.00888
339	Misc. Primary Metal Products	8.84	58.50	-0.00906	0.03214	0.06001	-0.00830	0.04874	0.09100	0.00121	0.09670	0.18055
342	Cutlery, Hand Tools, and Hardware	8.84	243.00	-0.00159	0.00498	0.01340	-0.00148	0.00753	0.02026	-0.00002	0.01490	0.04006
343	Plumbing and Heating (except Electric)	8.84	60.40	-0.00093	0.00257	0.00981	-0.00087	0.00386	0.01472	-0.00014	0.00757	0.02890
344	Fabricated Structural Metal Products	8.84	637.90	-0.00078	0.00140	0.00419	-0.00076	0.00199	0.00594	-0.00042	0.00367	0.01099
345	Screw Machine Products, Bolts, etc.	8.84	122.00	-0.00082	0.00145	0.00461	-0.00079	0.00204	0.00650	-0.00045	0.00376	0.01198
346	Metal Gorgings and Stampings	8.84	430.00	-0.00027	0.00051	0.00161	-0.00026	0.00073	0.00229	-0.00013	0.00137	0.00429
347	Metal Services	8.84	108.90	-0.00537	0.01335	0.03118	-0.00508	0.01974	0.04610	-0.00142	0.03620	0.08922
348	Ordnance and Accessories	8.84	62.20	-0.00003	0.00006	0.00028	-0.00003	0.00009	0.00036	-0.00001	0.00017	0.00069
349	Misc. Fabricated Metal Products	8.84	408.50	-0.00100	0.00237	0.00647	-0.00094	0.00349	0.00952	-0.00030	0.00673	0.01836
351	Engines and Turbines	8.41	297.60	-0.00006	0.00012	0.00031	-0.00006	0.00018	0.00047	-0.00003	0.00037	0.00093
352	Farm and Garden Machinery	8.41	287.50	-0.00057	0.00106	0.00328	-0.00055	0.00156	0.00481	-0.00026	0.00299	0.00923
353	Construction and Related Machinery	8.41	831.00	-0.00042	0.00082	0.00164	-0.00040	0.00121	0.00243	-0.00018	0.00235	0.00469
354	Metalworking Machinery	8.41	362.90	-0.00211	0.00256	0.00669	-0.00207	0.00343	0.00896	-0.00157	0.00593	0.01551
355	Special Industrial Machinery	8.41	214.90	-0.00063	0.00050	0.00186	-0.00063	0.00058	0.00214	-0.00059	0.00079	0.00294
356	General Industrial Machinery	8.41	468.90	-0.00183	0.00439	0.01119	-0.00172	0.00666	0.01697	-0.00042	0.01323	0.03368
357	Office and Computing Machines	8.41	480.30	-0.00026	0.00056	0.00134	-0.00025	0.00083	0.00200	-0.00009	0.00163	0.00391
358	Refrigeration and Service Machinery	8.41	183.20	-0.00039	0.00062	0.00306	-0.00038	0.00090	0.00439	-0.00022	0.00168	0.00824
359	Misc. Machinery, except Electrical	8.41	302.10	-0.00708	0.00827	0.01596	-0.00695	0.01096	0.02115	-0.00541	0.01874	0.03616
361	Electric Distributing Equipment	4.50	85.30	-0.00228	0.00768	0.01099	-0.00200	0.01365	0.03375	0.00141	0.03089	0.07640
362	Electrical Industrial Apparatus	4.50	289.10	-0.00075	0.00157	0.00206	-0.00070	0.00263	0.00346	-0.00010	0.00569	0.00749
364	Electric Lighting and Wiring Equip.	4.50	162.10	-0.00408	0.01382	0.02817	-0.00359	0.02461	0.05015	0.00259	0.05577	0.11368
366	Communication Equipment	4.50	512.00	-0.00162	0.00546	0.00917	-0.00142	0.00972	0.01632	0.00102	0.02204	0.03701
367	Electronic Components and Accessories	4.50	650.50	-0.00168	0.00471	0.00405	-0.00151	0.00823	0.00708	0.00050	0.01846	0.01583
369	Misc. Electrical Equip. and Supplies	4.50	223.70	-0.00083	0.00088	0.00122	-0.00082	0.00122	0.00167	-0.00063	0.00218	0.00300
371	Motor Vehicles and Equipment	3.62	54.60	-0.00021	0.00042	0.02652	-0.00020	0.00068	0.04320	-0.00005	0.00145	0.09140
372	Aircraft and Parts	3.62	431.10	-0.00180	0.00628	0.01238	-0.00158	0.01101	0.02170	0.00113	0.02468	0.04863
376	Guided Missiles, Space Vehicles, Parts	3.62	125.90	-0.00037	0.00131	0.00269	-0.00032	0.00231	0.00474	0.00025	0.00514	0.01068
379	Misc. Transportation Equipment	3.62	47.90	-0.00179	0.00112	0.00264	-0.00179	0.00112	0.00264	-0.00179	0.00112	0.00264
381	Engineering and Scientific Instruments	10.13	44.40	-0.00235	0.00446	0.01879	-0.00216	0.00871	0.03670	0.00028	0.02094	0.00845
382	Measuring and Controlling Devices	10.13	160.10	-0.00278	0.00694	0.02714	-0.00244	0.01432	0.05598	0.00178	0.03563	0.13932
401	Railroads - Maintenance	1.20	724.70	-0.00031	0.00036	0.00011	-0.00029	0.00076	0.00023	-0.00006	0.00191	0.00059
458	Air Transport - Maintenance	3.62	559.60	-0.01846	0.02685	0.00643	-0.01683	0.06223	0.01490	0.00343	0.10447	0.03938
753	Auto Repair	3.08	824.10	-0.05378	0.03366	0.01647	-0.05378	0.03366	0.01647	-0.05378	0.03366	0.01647

Source: References 5, 57 and 58; Table 8-20.

Note: Normal profit calculated for each industry by multiplying value of output by normal.

required on OTVD's, as is assumed in scenario 3, the picture becomes relatively less favorable for a number of industries, particularly SIC's 339, 364, and 358, where installed capital costs of pollution controls are respectively 9.7 percent, 5.6 percent and 16.4 percent of normal profits.

The ratio of installed capital cost to normal investment provides an additional measure of the ease or difficulty with which an affected firm will be able to fund purchases of the pollution control equipment. Further, it indicates the degree of dislocation to which the firm's investment strategy will be subjected by its need to meet the control requirements. Again, under options 1 and 2, for all industries this ratio is relatively small, rising above 5 percent in only two industries (SIC's 339 and 382). In no industry does the installed capital costs of pollution controls rise above 10 percent of normal investment levels. Under option 3 the picture changes slightly. The ratio exceeds 10 percent in 3 industries (SIC's 339, 364 and 382) and lies in the range of 5 to 10 percent for five others (SIC's 254, 347, 361, 371 and 381). This suggests that firms in some industries would have some difficulty in funding the purchase of carbon adsorbers for open top vapor degreasers.

b) Full-Cost Absorption Scenarios (4-6). In scenarios 4-6 it is assumed that firms absorb any cost changes instead of passing those changes on to consumers in the form of higher or lower prices. Thus firms are assumed to retain cost savings or absorb cost increases in the form of higher or lower profits. The extent to which profit levels would rise or fall under scenarios 4-6 is indicated by the ratio of total annualized cost changes to normal profits. In all industries, for all scenarios, that ratio is very small. Only for two industries (SIC's 458 and 753) does the ratio of the change in annualized costs to normal profits rise above 1 percent in any scenario. Under scenario 3 the largest value of the ratio for an industry experiencing cost increases is 0.343 percent.

The low values of the ratios of annualized cost changes to normal profits indicate that profit levels in solvent metal degreasing industries will change very little if firms follow cost absorption policies. Consequently the discussion of capital funding under scenarios 1-3 presented above may be applied to scenarios 4-6.

8.4.4.5. Demand for Degreasing Equipment and Solvent.

a) Degreasing Equipment. Tables 8-23 and 8-24 present the total changes in numbers of degreasing units generated by scenarios 1-3. The net impact on numbers of degreasers is very small both for each type of degreaser in each industry and in total. In fact, only in one industry, SIC 753, did the use of a type of degreaser (cold cleaners) measurably rise. Under all scenarios changes in numbers of open top vapor degreasers and conveyorized degreasers are negligible. For cold cleaners, the largest increase occurs in SIC code industry 73 and represents only 0.05 percent of pre-standard usage.

Table 8-24 clearly indicates that the net increase in the desired stock of degreasing units resulting from any control regulation will be negligible. On the other hand, it is possible that some increase in replacement investment could occur as promulgation of the regulatory controls may bring the existence of the cost savings to be achieved through the use of controlled equipment to the attention of degreaser users. Thus it is possible that producers of degreasers will be faced with an increase in demand for their

Table 8-23. Post Standard Use of Degreasing Equipment: By Industry.

SIC	Industry Short Title	Pre-Standard Numbers of Degreasers			Post-Standard Numbers of Vapor Degreasers								
					Scenario 1			Scenario 2			Scenario 3		
		Cold Cleaners	Open Top Vapor Degreasers	Conveyorized Vapor Degreasers	Cold Cleaners	Open Top Vapor Degreasers	Conveyorized Vapor Degreasers	Cold Cleaners	Open Top Vapor Degreasers	Conveyorized Vapor Degreasers	Cold Cleaners	Open Top Vapor Degreasers	Conveyorized Vapor Degreasers
39	Miscellaneous Industry	15936	614	73	15937	614.00	73.0	15937	614.03	73.0	15936	614.01	73.0
254	Partitions and Fixtures	6156	351	117	6157	351.00	117.0	6157	351.00	117.0	6156	351.01	117.0
259	Misc. Furniture and Fixtures	3265	109	36	3266	109.02	36.0	3266	109.02	36.0	3265	109.01	36.0
332	Iron and Steel Foundries	1992	137	34	1992	137.00	34.0	1992	137.00	34.0	1992	137.00	34.0
335	Nonferrous Rolling and Drawing	2246	277	70	2246	277.00	70.0	2246	277.00	70.0	2246	277.00	70.0
336	Nonferrous Foundries	4058	105	25	4058	105.00	25.0	4058	105.00	25.0	4058	105.00	25.0
339	Misc. Primary Metal Products	9715	1254	313	9723	1255.00	313.2	9722	1254.92	313.2	9714	1253.87	312.9
342	Cutlery, Hand Tools, and Hardware	11891	1152	280	11893	1152.16	280.0	11893	1152.15	280.0	11891	1152.00	280.0
343	Plumbing and Heating (except Electric)	2772	205	49	2772	205.02	49.0	2772	205.02	49.0	2772	205.00	49.0
344	Fabricated Structural Metal Products	25131	771	187	25133	771.05	187.0	25133	771.05	187.0	25132	771.03	187.0
345	Screw Machine Products, Bolts, etc.	5409	160	39	5409	160.01	39.0	5409	160.01	39.0	5409	160.01	39.0
346	Metal Gorgings and Stampings	5892	205	50	5892	205.00	50.0	5892	205.00	50.0	5892	205.00	50.0
347	Metal Services	19157	1124	273	19166	1124.53	273.1	19166	1124.50	273.1	19159	1124.14	273.0
348	Ordnance and Accessories	132	5	1	132	5.00	1.0	132	5.00	1.0	132	5.00	1.0
349	Misc. Fabricated Metal Products	16024	864	209	16025	864.08	209.0	16025	864.07	209.0	16024	864.02	209.0
351	Engines and Turbines	792	33	6	792	33.00	6.0	792	33.00	6.0	792	33.00	6.0
352	Farm and Garden Machinery	8238	304	65	8238	304.01	65.0	8238	304.01	65.0	8238	304.01	65.0
353	Construction and Related Machinery	11089	451	96	11089	451.02	96.0	11089	451.02	96.0	11089	451.01	96.0
354	Metalworking Machinery	38152	569	122	38159	569.10	122.0	38159	569.10	122.0	38157	569.08	122.0
355	Special Industrial Machinery	10467	41	9	10468	41.00	9.0	10468	41.00	9.0	10468	41.00	9.0
356	General Industrial Machinery	30734	1876	402	30739	1876.29	402.0	30738	1876.27	402.0	30735	1876.07	402.0
357	Office and Computing Machines	4589	220	47	4589	220.00	47.0	4589	220.00	47.0	4589	220.00	47.0
358	Refrigeration and Service Machinery	6085	169	35	6085	169.01	35.0	6085	169.01	35.0	6085	169.00	35.0
359	Misc. Machinery, except Electrical	79547	1085	232	79594	1085.65	232.1	79594	1085.63	232.1	79583	1085.49	232.1
361	Electric Distributing Equipment	3945	871	115	3945	871.09	115.0	3945	871.00	115.0	3945	870.94	114.9
362	Electrical Industrial Apparatus	4138	279	36	4138	279.01	36.0	4138	279.01	36.0	4138	279.00	36.0
364	Electric Lighting and Wiring Equip.	10935	2465	324	10937	2465.45	324.0	10937	2465.40	324.0	10934	2464.71	323.9
366	Communication Equipment	11339	2539	333	11340	2539.18	333.0	11340	2539.16	333.0	11338	2538.88	332.9
367	Electronic Components and Accessories	10196	1362	178	10197	1362.10	178.0	10197	1362.09	178.0	10196	1361.97	177.9
369	Misc. Electrical Equip. and Supplies	4989	71	10	4989	71.00	10.0	4989	71.00	10.0	4989	71.00	10.0
371	Motor Vehicles and Equipment	10944	630	89	10944	630.00	89.0	10944	630.00	89.0	10944	630.00	89.0
372	Aircraft and Parts	11967	2779	393	11968	2779.18	393.0	11968	2779.16	393.0	11967	2778.89	392.9
376	Guided Missiles, Space Vehicles, Parts	716	178	25	716	178.00	25.0	716	178.00	25.0	716	178.00	25.0
379	Misc. Transportation Equipment	4358	0	0	4358	0.00	0.0	4358	0.00	0.0	4358	0.00	0.0
381	Engineering and Scientific Instruments	6086	550	32	6087	550.13	32.0	6087	550.12	32.0	6086	549.98	31.9
382	Measuring and Controlling Devices	17797	3194	187	17802	3194.90	187.0	17801	3194.79	187.0	17794	3193.42	186.9
401	Railroads - Maintenance	1161	61	0	1161	61.00	0.0	1161	61.00	0.0	1161	61.00	0.0
458	Air Transport - Maintenance	36160	3279	0	36184	3281.19	0.0	36182	3281.00	0.0	36156	3278.59	0.0
753	Auto Repair	468027	0	0	468333	0.00	0.0	468333	0.00	0.0	468333	0.00	0.0

Sources: Table 8-3 and 8-18.

Table 8-24. Total Utilization of Degreasing Equipment in SIC's 25, 33-39, 401, 458 and 473

	Numbers of Cold Cleaners	Numbers of Open Top Vapor Degreasers	Numbers of Conveyorized Vapor Degreasers
Pre-Standard Level	922,227	30339	4492
Scenario 1 (NSPS 1)	922,655	30346	4493
Scenario 2 (NSPS 2)	922,649	30346	4493
Scenario 3 (NSPS 3)	922,571	30338	4492

Source: Table 8-23.

products as firms seek to replace old machinery with the new and more efficient equipment. It should be noted that an increase in replacement investment would occur even if controls were not introduced as the proposed technologies reduce firm operating costs. Nevertheless, the standards should stimulate the rate of replacement investment by providing solvent metal degreasers with improved information on their degreasing operations. In many plants degreasing costs form such a small fraction of total costs that they are likely to be ignored in firm decision making unless companies are forcibly required to examine them. Such an examination will be required of degreasing firms under any of the proposed regulatory controls.

b) Solvent Use. Average solvent savings per degreaser resulting from the implementation of the control options could not be estimated because of the unavailability of adequate data on the extent to which such controls are already in use. Nevertheless, it is likely that solvent use will fall below what it would otherwise have been as firms replace worn out uncontrolled degreasers with new controlled degreasers. To the extent that this happens, solvent producers will be faced with a decline in demand for their product. It is not clear, however, that this decline in demand for solvent by degreaser users would lead to lay offs and plant shutdowns. As was noted in section 8.1.1, the level of solvent use will tend to increase over time as the economy expands. Thus, the increase in solvent demand attributable to economic growth may offset the decline in solvent demand caused by the use of controlled degreasers with lower emmission rates.

8.4.5 Summary and Comparison of Economic Impacts.

Table 8-25 presents the estimated ranges of possible output, employment and price impacts associated with each of the three control options. The minimum (zero) impacts are those implied by the full-cost absorption model.

Table 8-25 Summary of Economic Impacts

	Option 1	Option 2	Option 3
Output Impacts ($\$10^6$)	40.3	38.2	13.3
Employment Impacts (jobs per year)	1075	1035	534
Inflationary Inputs (percent change in the CPI)	-0.015	-0.015	-0.013

Sources: Tables 8-18 and 8-19.

The maximum impacts are those implied by the full-cost pricing model. For each control option the minimum impacts are the same--none. Maximum possible impacts for employment and output are smallest under option 1, next smallest under option 2 and largest under option 3. The maximum inflationary impacts are identical under options 1 and 2 (0.015 percent) and fractionally smaller under option 3 (+0.013 percent). Any price, employment and output impacts associated with the implementation of the regulations are likely to be favorable (i.e., increases in output and employment and a decrease in the rate of inflation) because the proposed controls will result in cost savings for affected firms.

It must be emphasized that it was not possible to determine where, within the estimated impact ranges, the actual impacts would lie. Data on the extent to which controls are already being utilized by firms, the impact of the controls on retrofits and replacement rates, and market structures in each of the 39 affected industries would be required to increase the precision of the analysis. Such information was not available in the context of this study.

8.5 POTENTIAL SOCIO-ECONOMIC AND INFLATIONARY IMPACTS

The proposed new performance standard, whose economic impacts lie between those estimated for control options 1 and 2 in section 8.4, will have negligible impacts on the following key variables: compliance costs, total additional costs of production of major industry products and services, net national energy consumption, and use of key metals and chemicals.

8.5.1 Annualized Costs of Compliance

Annualized costs of compliance are zero or negative for all of the control options considered in the economic impact analysis. The maximum possible annualized cost reductions for options 1, 2, and 3 are $53.5 million, $51.5 million and $26.4 million, respectively. Cost reductions are likely to occur because solvent savings from the use of the degreasing controls are greater than the costs of the required capital equipment.

8.5.2 Total Costs of Production for Major Industries

Under control options 1 and 2 all industries will experience some cost savings. In none of the 11 industries experiencing costs increases under control option 3 is the estimated annualized cost increase greater than 0.2 percent, well below the criterion for regulatory action of 5% of the selling price of the industry products.

8.5.3 Net National Energy Consumption

There will be a small increase in energy consumption resulting from the implementation of each control option as the operation of carbon adsorbers requires electricity and steam and refrigerated freeboard chillers use electricity. Energy impacts for the base year (1976) were calculated by multiplying numbers of each type of degreaser in use by unit control energy requirements. This procedure provides a maximum estimate of the increase in net energy usage. For control options 1, 2, and 3 the annual net increase in energy use was estimated to be 0.613 trillion BTU's, 0.845 trillion BTU's and 1.55 trillion BTU's, respectively. These estimates amount to 296, 408, and 748 barrels of oil per day equivalent, respectively.* Assuming an increase in the use of all degreasers of 50 percent between 1976 and 1985 (estimated on the basis of the projections presented in Table 8-6), by 1985 the maximum net energy impact of control options 1, 2, and 3 would be 444, 612, and 1122 barrels of oil equivalent per day. These impacts are well below the criterion of 25,000 barrels of oil per day and may be regarded as negligible.

8.5.3.1 Energy Conservation

As noted in Section 7.4.4, the quantity of oil conserved through the use of solvents recovered from carbon adsorption units will be over 6500 barrel per day by 1985. This would represent a reduction of less than 0.003% in total daily domestic petroleum consumption. The energy cost coavings would be over $104,000 per day, based on an average OPEC price for oil of $16.00 per barrel during 1979.

8.5.4 Impact on the Demand for Metals, Plastics, and Chemicals

The proposed controls impact broadly upon all metal-using manufacturing industries and are likely to have a negligible or a small positive effect on output levels. However, as no manufacturing industry is likely to experience an increase in output of more than 0.1 percent, it is believed that the demand for steel in all forms, aluminum, copper, manganese, magnesium, and zinc will not increase by more than that amount and will not fall. The demand for plastics, synthetic rubber, urea, ammonia, and pulp will be similarly unaffected. As total solvent production constitutes less than 1 percent of the value of output of synthetic organic chemicals the controls are unlikely to reduce the demand for, and output of, ethylene and ethylene glycol by more than that amount. All of these impacts are well below the criterion for regulatory action of 3 percent.

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*The following conversion factor is used:

5.675×10^6 BTU's = 1 barrel of oil.

8.5.5 Reliability of the Impact Estimates

The results of the economic impact analysis are reliable in the following sense. The range of maximum and minimum economic impacts was calculated. In all cases the maximum advance economic impacts are well within the limits established by the criteria for regulatory analysis and it is most probable that the actually economic impacts resulting from the proposed controls will be much smaller.

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9. RATIONALE FOR THE PROPOSED STANDARDS

9.1 SELECTION OF SOURCE FOR CONTROL

Organic solvent cleaners (degreasers) have been identified as significant sources of air pollutant emissions which cause or contribute to the endangerment of the public health or welfare. Degreasing is not an industry but is an integral part of many manufacturing, repair, and maintenance operations. Volatile organic compounds, as well as 1,1,1-trichloroethane, trichlorotrifluoroethane, methylene chloride, trichloroethylene, and perchloroethylene constitute the emissions from organic solvent cleaners. There were an estimated 725,000 megagrams (800,000 tons) of organic solvents emitted from organic solvent cleaning operations in 1975. This represents about 4 percent of total national volatile organic emissions from stationary sources, making organic solvent cleaners the fifth largest stationary source category for organic emissions. There are over 1,500,000 organic solvent cleaners currently in operation. If the current growth rate of 4.1 percent per year continues as expected, over 300,000 new organic solvent cleaners would be subject to these standards of performance by 1985.

Degreasing emissions include losses due to evaporation from the solvent bath, convection, carryout, leaks, and waste solvent disposal. Thus, the emissions from a degreaser are fugitive in nature. Many of the degreasers currently in use are operated without proper control of emissions to the atmosphere. Emissions from degreasers may be controlled by the use of various equipment options (including a cover, extended freeboard, refrigerated freeboard device and carbon adsorber) and specific work practices (involving parts handling, proper use and maintenance of equipment, preventing drafts and controlling the rate of the degreasing operation).

Based on the large number of sources and their wide geographic distribution across the United States, the current sales and projected growth rate in the "industry" and the possible reduction in adverse environmental and health impacts which can be achieved, organic solvent cleaners have been selected for control through the development of standards of performance.

9.2 SELECTION OF POLLUTANTS AND AFFECTED FACILITIES

9.2.1 Selection of Pollutants.

Among the solvents used in degreasing operations, approximately 40 percent are non-halogenated hydrocarbons and 60 percent are halogenated hydrocarbons. Most of these solvents are also reactive volatile organic compounds (VOC), defined by this proposal as organic compounds which participate in atmospheric photochemical reactions or which may be measured by the applicable reference method specified under any subpart of 40 CFR Part 60. The proposed standards of performance apply to reactive VOC (ozone precursors) used as cleaning solvents and to five halogenated compounds for which there is a reasonable anticipation of public health endangerment.

9.2.1.1 Reactive Volatile Organic Compounds (VOC). The proposed standards require control of any VOC demonstrated to be precursors to the formation of ozone and other photochemical oxidants in the atmosphere. The Administrator has previously determined through the promulgation of a National Ambient Air Quality Standard (44 FR 8202, February 8, 1979) that ozone air pollution endangers public health and welfare.

While not all compounds are equally reactive, analysis of available data indicates that very few VOC are of such low photochemical reactivity that they can be ignored in oxidant control programs. EPA's "Recommended Policy on Control of Volatile Organic Compounds" (42 FR 35314, July 8, 1977) affirmed that many compounds which produced negligible oxidant concentrations during initial smog chamber tests were found to contribute appreciably to ozone levels when exposed to multiday irradiations in urban atmospheres. In those geographical areas where industrial and automotive emissions are subjected to long hours of sunlight, or where air stagnation occurs frequently, such low reactivity compounds may become a significant source of photochemical oxidant.

The photochemically reactive compounds, as a class, have been interpreted to constitute a "criteria pollutant" under Section 108 of the Clean Air Act, since the primary attainment strategy for the ozone ambient standard is to reduce air emissions of ozone precursors. Standards of performance may be developed for new sources of this pollutant class under section 111(b) of the Act. For some reactive VOC, however, health concerns other than contribution to ozone formation may be foremost. Where this is the case, regulation as a criteria pollutant may not be appropriate. The Clean Air Act provides for the designation of such substances for new source regulation under section 111(d) if the substances themselves have not been listed previously either under section 108 or section 112 (National Emission Standards for Hazardous Air Pollutants).

This designation invokes a provision of this section which requires the development of plans by individual States to control existing sources as well. The reactive halogenated compounds, perchloroethylene and trichloroethylene, are designated in this proposed rulemaking for the reasons discussed below.

Trichloroethylene and, to a lesser extent, perchloroethylene react to form ozone and therefore would be subject to new source performance standards for reactive VOC. In addition, there is evidence that both of these chemicals may present carcinogenic risks to human health. Though the data are not yet conclusive, both have been found to induce a high incidence of hepatocellular carcinomas (liver tumors) in mice and have received positive results in bacterial mutagenicity assays (a screening technique for potential carcinogens). Based on the weight of evidence, EPA's Carcinogen Assessment Group has concluded, in preliminary assessments, that there is substantial evidence that both perchloroethylene and trichloroethylene are human carcinogens. If further review and analysis affirm these conclusions, both chemicals would become candidates for section 112 regulation as "high probability" carcinogens under EPA's proposed airborne carcinogen policy. In the interim, however, the Administrator has determined that, despite the present uncertainties in the health data, there is sufficient evidence at this time to consider both perchloroethylene and trichloroethylene as air pollutants which may reasonably endanger public health and that it is appropriate to proceed with the designated pollutant regulatory path. In the event that EPA subsequently lists either substance as a hazardous air pollutant under section 112, the reduction in health risk obtained by the regulations proposed today will be a major factor in the determination of the need for further control in this industry.

9.2.1.2 Negligibly Reactive Halogenated Compounds. In addition to reactive halogenated compounds, the proposed new source regulations would apply to three additional halogenated solvents: 1,1,1-trichloroethane, methylene chloride, and trichlorotrifluoroethane. Since these chemicals are acknowledged by EPA to be neglibibly reactive, they are not ozone precursors and must be designated under section 111(d) of the Act. As described above, the designation for the purpose of obtaining coverage under new source standards also requires the development under section 111(d) of standards for existing sources.

Both methylene chloride and 1,1,1-trichloroethane have scored positive as well as negative results in short-term mutagenicity and cell transformation tests. The weight of evidence has led the EPA Carcinogen Assessment Group to conclude in preliminary assessments that both chemicals exhibit suggestive evidence of human carcinogenicity. Under EPA's proposed airborne carcinogen policy, this finding would establish 1,1,1-trichloroethane and methylene chloride as candidates for regulation under section 111 as air pollutants "reasonably anticipated to endanger public health welfare." In addition, trichlorotrifluoroethane and 1,1,1-trichloroethane have been implicated in the depletion of the stratospheric ozone layer, a region of the upper atmosphere which shields the earth from harmful wavelengths of ultraviolet radiation that increase skin cancer risks in humans.

The judgments of whether and to what extent 1,1,1-trichloroethane and methylene chloride are human carcinogens, and 1,1,1-trichloroethane and trichlorotrifluoroethane deplete the ozone layer, are issues of considerable debate. While the scientific literature has been previously reviewed and summarized in the docket prepared for this rulemaking, more detailed health assessments are currently in preparation by EPA's Office of Research and Development. These assessments will be completed and submitted for external review, including review by the Science Advisory Board, prior to the promulgation of the regulations and the proposal of EPA guidance to States in developing existing source control measures. The extent to which the preliminary findings are affirmed by the review process may affect the final rulemaking for new as well as existing sources.

While the measure of concern is less for these latter three solvents than for perchloroethylene and trichloroethylene, the Administrator has chosen to proceed with the designation of 1,1,1-trichloroethane, methylene chloride, and trichlorotrifluoroethane at this time because emissions from these sources and the associated health risks can be reduced at a very low cost. This decision reflects EPA's concern that continued growth in uncontrolled emissions of 1,1,1-trichloroethane, methylene chloride, and trichlorotrifluoroethane from solvent cleaners may endanger public health, and is reinforced by projections that, were these chemicals exempted from regulation, the resulting substitution of exempt for non-exempt solvents could result in large increases in the emissions of these pollutants.

The designation of 1,1,1-trichloroethane, methylene chloride, and trichlorotrifluoroethane incorporates these chemicals under today's proposed new source standards and invokes section 111(d) which requires States to develop controls for existing sources. As described in detail below, the new source standards do not place unreasonable economic costs on the industry. While the impact of similar controls on existing sources could be more significant due to the technological problems associated with retrofit, this factor would be an important consideration in determining the appropriate control level for existing sources. In view of the substantial reduction in emissions which can be achieved at low cost, the Administrator is persuaded that the present approach represents a prudent policy to protect public health.

Summaries of the health basis for designating perchloroethylene, trichloroethylene, 1,1,1-trichloroethane, methylene chloride, and trichlorotrifluoroethane are available in the public rulemaking docket described at the beginning of this notice.

9.2.2 Selection of Affected Facilities.

Organic solvent cleaning is not a specific industry but is an integral part of many manufacturing, repair, and maintenance operations. Practically every business that works metal or has maintenance or repair operations does some type of degreasing. Degreasing operations are often concentrated in urban areas where there are a large number of manufacturing facilities.

The solvents used in degreasing operations include halogenated hydrocarbons, petroleum distillates, ketones, ethers, and alcohols. These solvents are emitted as fugitive emissions from each of the three types of degreasers which would be regulated: (1) a cold cleaner, in which the article to be cleaned is immersed, sprayed or otherwise washed in a solvent at or about room temperature; (2) an open top vapor degreaser, in which the article is suspended in solvent vapor over a pool of boiling solvent and the solvent vapors condense on the article and dissolve or wash soil and grease from it; and (3) a conveyorized degreaser, in which articles are conveyed on a chain, belt or other conveying system either through a spray or pool of cold solvent, or through the vapor of a boiling solvent. In order to achieve significant reduction in volatile organic compound emissions from degreasing operations, all types of new, modified, or reconstructed degreasers would be subject to control.

The mode of disposal of waste solvent can also contribute significantly to solvent emissions. Disposal is not usually handled by the owners of organic solvent cleaners, but by operators of landfills, incinerators, or solvent reclaiming facilities. If waste solvent disposal in 1985 were to follow the pattern of waste solvent disposal in 1974, about 43 percent of the waste solvent from new sources would be reclaimed or disposed of properly and the remaining 57 percent could be a source of air or water emissions. For this recovery, disposal of waste solvent, sump, and still bottoms has also been selected for development of standards of performance.

9.3 SELECTION OF THE BASIS OF THE PROPOSED STANDARDS

Emissions of volatile organic compounds from degreasers can be reduced significantly by the use of various pollution control devices, singly or in combination, as appropriate for each method of degreasing. These controls include: cover, drain rack, raised freeboard, refrigerated freeboard device, carbon adsorber, downtime port covers, silhouette cutouts or hanging flaps, and drying tunnel. Degreaser emissions can be reduced further through the implementation of prescribed work practices. These work practices include: closing the cover when work is not being lowered into or removed from the degreaser, storing solvent in covered containers, not exposing open degreasers to steady drafts with velocities exceeding 40 m/min (131 ft/min). and not overloading the degreaser.

The best system of emission control for each type of degreaser was selected on the basis of tests of the effectiveness of various controls operating under different conditions and using different solvents, as well as a cost analysis of each. These are described below.

Because of the diversity of the organic solvent cleaning industry, selection of the best emission control systems in this section are based on a specific set of scenarios. In certain instances, a different system from that selected here might be preferable because of economic and environmental considerations. For example, if sheet metal were being cleaned in a conveyorized vapor degreaser (CVD), the carryout would be small because the surface and the orientation of the work would enhance drainage. On the other hand, if finned condensing tubes were being cleaned, the carryout could be very large and a drying tunnel would be needed.

The cost/kg for degreaser emission controls is the net cost (or savings) divided by the kilograms of solvent controlled. The net cost (or savings) is the cost of the control minus the value of the solvent controlled. On a 1.86 m^2 (20 ft^2) open top vapor degreaser (OTVD), a refrigerated freeboard device saves twice the solvent as compared to a raised freeboard. The savings/kg are \$0.14 for the refrigerated freeboard device and \$0.28 for the raised freeboard. The magnitude of the savings/kg or the cost/kg depend on the workload and on the degreaser size. For large (5.6 m^2) OTVD used three shifts per day and active (uncovered) 75 percent of the time, the savings for a cover are $0.36/kg. Savings for a refrigerated freeboard device on the same OTVD are $0.39/kg.

From the above, it is evident that the definition as well as the selection of the best emission control system depends on degreaser type, size, and workload. Selection cannot be made solely on economic grounds since the control system with the largest saving/kg is usually the cheapest and usually produces the smallest reduction in the magnitude of solvent emissions. For these reasons, selection of the emission control systems is based primarily on absolute reduction in solvent emissions and secondarily on economic considerations (savings/kg).

Finally, selection of the control system is based on the assumption that the correct work practices outlined in Chapter 6 are followed. Control system economics cannot be defined if incorrect work practices are common. No costs are ascribed to work practices.

9.3.1 Selected Emission Control Systems for Cold Cleaners

The emission control system selected for cold cleaners (CC) would consist of both control equipment and a series of work practices. These controls used in combination would reduce solvent emissions from cold cleaners by about 80 percent. The equipment requirements would include a cover, a drain rack, and a visible fill line. The cover would be designed to be readily opened and closed at any time. External drain racks would lead the drainage back to the tank. If the CC is equipped with a parts basket, internal hooks to permit suspension of the basket above the solvent could be substituted for the drain rack. One of the work practices would require that the solvent level not exceed the visible internal maximum fill line. The proposed standards would require that the freeboard ratio for CC would be at least 0.7 if the solvent volatility is greater than 4.3 kPa (33 mm Hg or 0.6 psi) measured at 38°C (100°F). For solvents with a volatility of less than or equal to 4.3 kPa measured at 38°C (100°F), the proposed standards would require a freeboard ratio of 0.5.

The economic analysis for this emission control system for cold cleaners was based on a typical unit. The uncontrolled cold cleaner was assumed to be uncovered all the time, whereas the controlled unit had a cover that was used all but 2 hours per working day (20 loads cleaned per day). Based on these assumptions, the cover would reduce emissions by 349 kilograms (769 pounds) per year at a savings of $69.80. The drain rack would reduce emissions by 36 kilograms (79 pounds) per year with a savings of $7.92.

9.3.2 Selected Emission Contol Systems for Remote Reservoir Cold Cleaners

The emission control system selected for remote reservoir cold cleaners (RRCC) is less stringent than that proposed for conventional cold cleaners. During non-use periods, the solvent is enclosed in a reservoir and not subject to evaporation loss to the atmosphere. While parts are being cleaned, solvent is pumped through a sink-like work area which drains back into the enclosed container. Because the reservoir is remote from the work area, this type of organic solvent cleaner is not subject to evaporation losses suffered by conventional cold cleaners. Therefore, the proposed standards for remote reservoir cold cleaners would not require closable covers, provided the solvent used has a volatility of less than or equal to 4.3 kPa (33 mm Hg or 0.6 psi) measured at 38°C (100°F), but would require covers if the solvent volatility was greater than 4.3 kPa.

9.3.3 Selected Emission Control Systems for Open Top Vapor Degreasers

The emission control systems which would be required for all new, modified, or reconstructed open top vapor degreasers (OTVD) consist of covers, raised freeboards, refrigerated freeboard devices, and carbon adsorption systems.

EPA and industry tests have shown that covers are the most effective control device in reducing solvent emissions during non-operating conditions. Raised freeboards have also been shown to be effective at reducing these emissions. By raising the freeboard ratio from 0.5 to 0.75, solvent emissions are generally reduced 25-30 percent during idling conditions. Emission reductions are less during actual operating conditions due to the transference of loads through vapor/air interface. Freeboard ratios larger than 0.75 may yield greater emission reductions, however, higher freeboards tend to increase the difficulty of transferring loads into and out of the degreaser. The demonstrated ability of covers and raised freeboards to reduce solvent emissions, coupled with the minimal cost of these two control devices have been the primary reasons for requiring the use of covers during non-operating periods, and freeboard ratios of at least 0.75, regardless of OTVD size.

Emission tests have also shown that refrigerated freeboard devices and lip exhausts connected to carbon adsorbers are more effective at reducing solvent emissions than raised freeboards. During operating conditions, emission reductions as high as 65 percent have been demonstrated with the use of carbon adsorbers, while refrigerated freeboard devices have been demonstrated to reduce solvent emissions by at least 40 percent. For this reason, all new, modified, and reconstructed OTVD with vapor/air interface areas greater than one square meter would be required to use refrigerated freeboard devices or have lip exhausts connected to carbon adsorbers.

A cut-off size of one square meter was determined to be the most effective for OTVD, taking into consideration the absolute reduction in solvent emissions and economic considerations. Although the capital expenditures for refrigerated freeboard devices are greater than for raised freeboards, solvent savings would completely offset the added capital expenditures, provided the degreasers were operated properly. However, for small degreasers (less than 1 m^2 in open top area), refrigerated freeboard devices would not be a cost-effective alternative. Taking into consideration the small reduction in solvent emissions and economic considerations, small degreasers would not be required to have refrigerated freeboard devices.

EPA realizes that refrigerated freeboard devices with sub-zero (0°C) refrigerant temperatures are patented. If any degreaser manufacturer is unable to demonstrate alternative methods of control, or certifies that the licensing terms for sub-zero refrigerated freeboard devices are unreasonable, relief under section 308 of the Clean Air Act, as amended can be initiated.

These proposed standards which specify control technologies do not preclude the use of other secondary control options, provided they are equally effective in reducing solvent emissions. In fact, EPA expects to approve other methods of continuous emission reduction when they have been demonstrated to be as effective in reducing emissions as sub-zero refrigerated freeboard devices. Tests are currently being conducted to investigate the effectiveness of automated covers which close after the workload enters the degreaser and the use of increased freeboard ratios as high as 1.25.

Any additional information and data submitted to EPA from persons outside the Agency would be used to evaluate the appropriateness of secondary emission control options. Expansion or deletion of certain secondary emission control options would be made prior to promulgation when additional data and information becomes available. All information obtained during the course of this investigation and received during the public comment period would be placed in the docket for public review and considered by EPA before taking final action to promulgate standards for new, modified, or reconstructed degreasers.

9.3.4 Selected Emission Control Systems for Conveyorized Degreasers

There are two major types of conveyorized degreasers: conveyorized cold cleaners (CCC) and conveyorized vapor degreasers (CVD). The emission control systems selected for conveyorized degreasers consist of both control equipment and a series of work practices. Using these controls in combination will reduce solvent emissions from conveyorized degreasers by 60 percent. The two major emission control equipment requirements for conveyorized vapor degreasers are carbon adsorbers and refrigerated freeboard devices. Since refrigerated freeboard devices are not effective on conveyorized cold cleaners, and because uncontrolled emissions from CCC are twice as great as from CVD, all conveyorized cold cleaners greater than 2 square meters (43 ft^2) in air-solvent interface area would be required to use carbon adsorbers.

For larger crossrod and monorail CVD, carbon adsorbers produce greater emission reductions at higher savings than do refrigerated freeboard devices. For owners or operators of small crossrod and monorail degreasers, the capital costs of a carbon adsorber could be prohibitive. Because of this, a refrigerated freeboard device may be used instead of a carbon adsorber. As with OTVD, the type of conveyorized vapor degreaser, the type of work being processed, and ambient conditions would determine which emission control system should be used.

9.3.5 Selected Emission Control Systems for Waste Solvent Disposal Operations

Disposal of waste solvent from all organic solvent cleaning operations (new and old) would be regulated under the Resource Conservation and Recovery Act (RCRA) which was recently proposed by EPA (43 FR 58946). These regulations define halogenated and non-halogenated solvents, and solvent recovery still bottoms as hazardous wastes. Under RCRA, control of these wastes must be accomplished through the use of specific disposal techniques. Distillation is the preferred method for the control of waste solvent because it recycles the waste solvent thereby conserving national energy resources. Approximately one-half of all open top vapor degreasers, and almost all conveyorized degreasers use distillation as a method for recovering spent solvent. In addition, some manufacturers of cold cleaners recycle used solvent for their customers. However, distillation may not always be a viable alternative. RCRA also allows waste solvent, sump, and still bottoms to be disposed of by incineration, landfilling, or storage in surface impoundments or basins.

These proposed standards, in addition to RCRA, would prevent the discharge of waste solvent into surface impoundments and basins, and require that waste solvent disposed in landfills be deposited in closed containers prior to burial. These additional requirements are necessary to ensure that the waste solvents do not evaporate into the air during their disposal. Since waste solvent from all degreasing operations is subject to control under RCRA, any additional requiements imposed by these standards of performance would not cause an incremental increase in the amount of waste solvent disposed. Air emissions are also controlled under Department of Transportation regulations which prescribe methods of containerization and transportation of waste solvent, and by performance standards for incinceration under RCRA.

9.4 SELECTION OF FORMAT FOR THE PROPOSED STANDARDS

Under the Clean Air Act, as amended, there are two regulatory alternatives available for establishing standards of performance for new stationary sources. Section 111(b) provides for establishing emission limitations or percentage reductions in emissions. However, when such standards are not feasible to prescribe or enforce, section 111(h) of the Clean Air Act provides that EPA may instead promulgate a design, equipment, work practice, or operational standard, or combination thereof. In either event, the standards prescribed would require new, modified, and reconstructed organic solvent cleaners to use the best demonstrated system of continuous emission reduction considering costs, nonair quality health and environmental impacts, and energy impacts. The emissions from organic solvent cleaners are unconfined (fugitive). Although techniques have been developed to measure the solvent lost from degreasing equipment (such as mounting entire organic solvent cleaners on scales), these methods are impractical for enforcement of regulations due to the length of time needed to accurately determine the solvent losses and because of the disruption this would cause in degreaser operations. For this reason, an equipment and work practice standard has been selected since it is not feasible to enforce emission limitations or percentage reductions in emissions for organic solvent cleaning operations.

9.5 SELECTION OF EMISSION LIMITS

Emissions from organic solvent cleaners, excepting those from carbon adsorption systems, are considered fugitive emissions. For reasons discussed in section 9.4, no limits are set for these fugitive emissions. An emission standard has been proposed for carbon adsorption control devices which requires that the concentration of solvent in the exhaust be less than 25 ppm of any regulated halogenated organic compound as measured by Method 23 for the length of the carbon adsorber cycle or three hours, whichever is less. If other volatile organic compounds are used, then the emissions shall not exceed an average of 25 ppm as carbon, measured by Method 25 for the length of the carbon adsorber cycle or three hours, whichever is less. The purpose of the proposed standard is to insure that carbon adsorption beds be regenerated before complete breakthrough occurs. Breakthrough occurs when a bed reaches capacity. During normal operation, the concentration of solvent vapor in the exhaust from an adsorber will be very low (<10 ppm). Upon breakthrough, the concentration will increase rapidly until it reaches the solvent concentration in the inlet stream. The operator of a degreaser with a carbon adsorption control system can estimate the amount of time which sould be allowed between one bed regeneration and the next using the bed capacity and the rate at which solvent is entering the bed. Since, the solvent input rate generally cannot be determined with accuracy, this method may not be practical. It would be necessary to regenerate the bed well before it reaches capacity to insure against operation after breakthrough. Another method of determining when to regenerate a carbon adsorber would be to monitor the concentration of solvent vapor in the bed exhaust. The 25 ppm concentration limit is based on the availability of continuous monitoring devices which can detect solvent vapors at this concentration level. Although a lower limit could have been set based on the demonstrated capability of carbon adsorption control systems, this would have required the use of sophisticated monitoring equipment to insure compliance. Also, because a good portion of the emissions from a degreaser equipped with a carbon adsorber are fugitive emissions not ducted to the adsorber, the benefit to be gained by setting an extremely low limit on carbon adsorber emissions would be minimal.

9.6 MODIFICATION/RECONSTRUCTION CONSIDERATIONS

The proposed standards apply to all organic solvent cleaners which are constructed or modified on or after the date of proposal. Provisions for modification and reconstruction are discussed in Chapter 5 along with the various physical and operational changes that are expected to occur to organic solvent cleaners.

9.6.1 Potential Modifications

Six alternatives are considered for potential modifications in degreasing facilities:

- Routine maintenance, repair, and replacement,
- Alternative solvents,
- Addition of a system which controls air pollutants,
- Increase in production rate without a capital expenditure,
- Equipment relocation, and
- Removal or disabling of a control device.

Routine maintenance, repair, or replacement are not considered modifications under 40 CFR 60.14(e)(1). These operations will not result in an increase in emissions assuming that proper operational procedures are followed during maintenance, repair, or replacement operations and if replacement materials are identical in type and quantity to the original.

The use of an alternative solvent is not considered to be a modification, under 40 CFR 60.14(e)(4), if the existing facility was designed to accommodate it and no modification of the degreaser is required.

The addition of an air pollution control system to a degreaser is not considered a modification under 40 CFR 60.14(e)(5) because it reduces air pollutants and is therefore environmentally beneficial.

The substitution of one control device for an existing device would not be considered a modification if it is determined by the EPA that the control device being added is more environmentally beneficial. The intent of this type of exemption is to encourage emission reductions on existing facilities which would otherwise not be regulated under the proposed standard.

An increase in the production rate of an existing degreasing facility is not considered a modification under 40 CFR 60.14(e)(2). When a need for capital expenditure is required to increase the production rate of a degreaser, the degreaser is then modified and subject to the proposed NSPS.

Equipment relocation within the same plant does not contribute to an increase of emission level and, therefore, is not considered a modification.

The removal or disabling of a device, on an existing degreaser, which controls solvent emissions is a modification. In addition, an operational change to an existing facility which results in an increase in emissions is a modification under 40 CFR 60.14(a). As an example, if a hoist speed is modified to process work at a faster rate than is currently in practice, then that degreaser is modified. The intent is to prevent as much as possible an increase in emissions from existing degreasers which are not regulated under the proposed standard and which may not be regulated under state or local law.

9.6.2 Reconstruction

Major reconstruction of a degreasing facility is not generally undertaken except for large, complex, custom-designed, conveyorized systems.

Four cases are considered for potential reconstruction:

- Replacement of a freeboard chiller,
- Rebodying of a degreaser,
- Replacement of a gas-fired or steam heater in a degreaser by an electric heating system, and
- Rebuilding of a custom-built degreaser.

All these cases could cost more than 50 percent of the capital cost of a new degreaser; they would therefore constitute reconstruction under 40 CFR 60.15 and be subject to the proposed standards. However, for rebuilding of a customized degreaser, it may be technically infeasible to comply with the proposed standard. Technical infeasibility may result from an uncorrectable condition, e.g., space limitation in the affected facility. Therefore, under such conditions, the existing facility may not be considered as reconstructed under 40 CFR 60.15(b)(2).

9.7 SELECTION OF PERFORMANCE TEST METHODS

Reference Methods 23 and 25 are proposed as methods for measuring organic solvent vapor concentrations in exhaust streams from carbon adsorption systems. Reference Method 23 is proposed for addition to Appendix A to CFR Part 60 concurrent with the proposal of the organic solvent cleaning new source performance standards (NSPS) and Reference Method 25 is proposed with the Automobile and Light Truck Surface Coating NSPS (44 FR 57792, October 5, 1979).

APPENDIX A. EVOLUTION OF THE PROPOSED STANDARDS

In 1974 the EPA contracted the Dow Chemical Company in Midland, Michigan to study solvent metal cleaning as a source of volatile organic emissions (EPA contract 68-02-1329, Task Order No. 9). In 1977 the EPA issued a Control Techniques Guideline Document to the states based on the compiled information. The CTG was a guide to the States for controlling volatile organic emissions from existing degreasing operations. The MITRE Corporation began to assist EPA in developing a New Source Performance Standard for Organic Solvent Cleaners after it was established that degreasing facilities are a major source of volatile organic compounds. Information which describes the type and level of emissions from the various kinds of degreasers was obtained from both EPA and industry. GCA/Technology Division began assistance to EPA in developing this standard in January 1979.

A.1 Chronology

The chronology which follows includes those events which have occurred in developing the NSPS for organic solvent cleaners, including the activities of the Dow Chemical Company in compiling the data for the support document. Anticipated events which lead up to the proposal of the standard in the *Federal Register* are also included.

Date	Activity
December 13, 1974	Visit to VIC Manufacturing in Minneapolis, Minnesota
January 9 - February 3, 1975	Degreasing plant interviews conducted by National Marketing Surveys. Interviews were conducted at 2578 plants.
January 15, 1975	Visit to Graymills Corporation in Chicago, Illinois
January 16, 1975	Visit to Baron-Blakeslee in Chicago, Illinois
January 16, 1975	Visit to Phillips Manufacturing Company in Chicago, Illinois
January 23, 1975	Visit to Kleer-Flo Corporation in Eden Prairie, Minnesota
March 4, 1975	Visit to Olson Manufacturing in Holden, Massachusetts
March 4, 1975	Visit to J. L. Thompson in Waltham, Massachusetts
March 5, 1975	Visit to Anson Incorporated in Providence, Rhode Island
March 5, 1975	Visit to Guild Metal Products, Inc. in Providence, Rhode Island
March 6, 1975	Visit to Pratt Whitney Aircraft in E. Hartford, Connecticut
March 7, 1975	Visit to Detrex Chemical Industries, Inc. in Detroit, Michigan

March 11, 1975	Visit to Western Electric Company-Hawthorne Plant in Chicago, Illinois
March 13, 1975	Visit to Rockford Products Company in Rockford, Illinois
March 25, 1975	Visit to Safety Kleen Corporation in Elgin, Illinois
May 19 - August 1975	Emission control testing of a carbon adsorber on an open top degreaser, performed at Super Radiator Corporation, St. Louis Park, Minnesota by Dow Chemical Company for EPA.
May 19 - August 15, 1975	Emission control testing of carbon adsorption for an open top degreaser at Vic Manufacturing Company, Minneapolis, Minnesota by Dow Chemical Company for EPA. Report completed on February 11, 1976.
May 19 and 27, 1975	Emission control testing of carbon adsorption for a crossrod degreaser at J. L. Thompson Co., Waltham, Massachusetts by Dow Chemical Co. for EPA.
May 21, 1975	Visit to General Motors Corporation - Diesel Equipment Division in Grand Rapids, Michigan
May 28, 1975	Visit to Hoyt Manufacturing in Westport, Massachusetts
May 29, 1975	Visit to Pratt Whitney Aircraft in E. Hartford, Connecticut
June 5, 1975	Visit to Westinghouse Electric Company in Raleigh, North Carolina
June 6, 1975	Visit to General Motors Corporation - Diesel Equipment Division in Grand Rapids, Michigan
June 10, 1975	Visit to Western Electric Company in Chicago, Illinois
June 12, 1975	Visit to Hamilton Standard - Division of United Technologies in Windsor Locks, Connecticut

June 12, 1975	Visit to Pratt Whitney Aircraft in E. Hartford, Connecticut
June 13, 1975	Visit to General Time Corporation in Thomaston, Connecticut
June 16 - August 1975	Emission control testing of carbon adsorption at Western Electric Company, Chicago, Illinois by Dow Chemical Company for EPA
June 20 - July 24, 1975	Emission control evaluation of (1) a pneumatic cover and (2) refrigeration, performed at Pratt Whitney, Hartford, Connecticut by Dow Chemical Company for EPA
June 24, 1975	Visit to Safety Kleen Corporation in Elgin, Illinois
June 25 - August 1, 1975	Emission control efficiency evaluation of two refrigerated freeboard chillers, performed at Hamilton Standard, Windsor Locks, Connecticut by Dow Chemical Company for EPA
July 1, 1975	Visit to Horton Company in Jackson, Michigan
July 3, 1975	Visit to Autosonics Company in Norristown, Pennsylvania
July 3, 1975	Visit to General Electric Corporation in Philadelphia, Pennsylvania
July 9-10, 1975	Emission control evaluation of carbon adsorption at Hewlett Packard Corporation, Loveland, Colorado by Dow Chemical Company for EPA
July 10 - November 1975	Emission control testing of a refrigerated freeboard chiller on a monorail vapor degreaser performed at Schlage Lock Company, Rocky Mount, N. C. by EPA.
July 28 - September 18, 1975	Emission testing of cold cleaners and vapor degreasers at Prestolite Corporation, Bay City, Michigan by Dow Chemical Company for EPA.

August 5 - October 4, 1975	Cost and energy comparative study between alkaline washing and vapor degreasing, performed by Dow Chemical Company at GMC, Grand Rapids, Michigan for EPA.
August 20, 1975	Visit to VIC Manufacturing in Minneapolis, Minnesota
September 9-11, 1975	Visit to VIC Manufacturing in Minneapolis, Minnesota
October 8, 1975	Visit to Baron-Blakeslee, Incorporated in Chicago, Illinois
October 8, 1975	Visit to Graymills, Incorporated in Chicago, Illinois
January 14, 1976	Meeting with ASTM Committee in Orlando, Florida
February 1976	Completion of a test report, "Control Efficiency of a Refrigerated Freeboard Chiller on a Monorail Vapor Degreaser," by EPA.
March 16, 1976	Visit to Magnus, Division of Economic Laboratories in St. Paul, Minnesota
March 16, 1976	Visit to Kleer-Flo Company in Eden Prairie, Minnesota
June 1976 (some data originally from 1961)	Emission control evaluation of vapor degreaser covers, performed at Eaton Corporation, Saginaw, Michigan by Dow Chemical Company for EPA.
June 1976	Emission control testing of increased freeboard on open top degreasers by Dow Chemical Company
June 30, 1976	Completion of "Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations," by Dow Chemical Co., Midland, Michigan.
November 3, 1976	First NAPCTAC meeting, San Francisco, California.
November 6, 1976	Visit to Rucker Ultrasonics in Concord, California

January 26-27, 1977	Meeting with ASTM Committee in New Orleans, Louisiana
January 27, 1977	Visit to Rollins Environmental Services in Baton Rouge, Louisiana
January 28, 1977	Visit to March Chemical Company in Denham Springs, Louisiana
May 1977	Completion of a test report, "Evaporative Emissions Study on Cold Cleaners," by EPA.
June 22, 1977	Meeting with ASTM Committee in Gatlinburg, Tennessee
July 21, 1977	Visit to Detrex Chemical Industries in Boiling Green, Kentucky
July 22, 1977	Visit to Autosonics, Inc. in Norristown, Pennsylvania.
August 1977	First issue paper was written by J. C. Shumaker and D. R. Patrick.
November 1977	Publication of the OAQPS Guidelines document, "Control of Volatile Organic Emissions from Solvent Metal Cleaning," EPA-450/2-77-022.
December 8, 1977	Meeting with ASTM, PEDCo Environmental and EPA-IERL in Cincinnati, Ohio
January 1978	Completion of a test report, "Solvent Drainage and Evaporation from Cold Cleaner Usage," by EPA.
January 25, 1978	Meeting with ASTM Committee in Fort Lauderdale, Florida
May 1978	Publication of EPA document, "Control of Volatile Organic Compounds from Stationary Sources," EPA-450/2-78-022.
May 26, 1978	Completion of issue paper.
June 22, 1978	Working Group meeting.
August 23, 1978	Second NAPCTAC meeting, Alexandria, Virginia.
May 1, 1979	Meeting with ASTM, PEDCo Environmental, and EPA-IERL in Cincinnati, Ohio.

June 1, 1979:	Steering Committee Meeting
June 12-13, 1979:	Visit to AutoSonics, Inc., in Norristown, Pennsylvania.
July 11, 1979:	Visit to Allied Chemical Corporation, Buffalo, New York to discuss emission test data on open top vapor degreasers.
July 12-15, 1979:	Visit to AutoSonics, Inc., in Norristown, PA.
To be scheduled:	Presentation of final preamble, regulation, and advance information memo for Assistant Administrator concurrence.
January, 1980 (anticipated)	Proposal of the New Source Performance Standard for Organic Solvent Cleaners

APPENDIX B

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

This appendix consists of a reference system, cross-indexed with the October 21, 1974, FEDERAL REGISTER (39 FR 37419) containing the Agency guidelines concerning the preparation of Environmental Impact Statements. This index can be used to identify sections of the document which contain data and information germane to any portion of the FEDERAL REGISTER guidelines.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
1. Background and description of the proposed action.	
-Describe the recommended or proposed action and its purpose.	The proposed standards are summarized in chapter 1, section 1.1. The statutory basis for the proposed standards (section III of the Clean Air Act, as amended) is discussed in the Introduction. The purpose of the proposed standards is discussed in chapter 9, sections 9.1 and 9.2.
-The relationship to other actions and proposals significantly affected by the proposed action shall be discussed, including not only other Agency activities but also those of other governmental and private organizations.	Water effluent limitations for solvent metal cleaners are discussed in chapter 7, section 7.2. Discussion of the economic impacts that the proposed new source performance standards may have on these effluent guidelines is presented in chapter 8.
2. Alternatives to the proposed action.	
-Describe and objectively weigh reasonable alternatives to the proposed action, to the extent such alternatives are permitted by the law. . . For use as a reference point to which other actions can be compared, the analysis of alternatives should include the alternative of taking no action, or of postponing action. In addition, the analysis should include alternatives having different environmental impacts, including proposing standards, criteria, procedures, or actions of varying degrees of stringency. When appropriate, actions with similar environmental impacts	The alternative control systems, based upon the best combinations of control techniques, are presented in chapter 4. A discussion to the alternative of taking no actions and that of postponing the proposed action is presented in chapter 7, section 7.6.1. The alternative systems are discussed throughout the document in the evaluation of the environmental and economic impacts associated with the proposed standards. The selection of the best system for emision reduction, considering costs, is presented in chapter 9, section 9.3.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT (continued)

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
but based on different technical approaches should be discussed. This analysis shall evaluate alternatives in such a manner that reviewers can judge their relative desirability.	The alternative formats for the proposed standards are discussed and the rationale for the selection of the proposed formats are discussed in chapter 9, section 9.4.
-Where the authorizing legislation limits the Agency from taking certain factors into account in its decision making, the comparative evaluation should discuss all relevant factors, but clearly identify those factors which the authorizing legislation requires to be the basis of the decision making.	The factors which the authorizing legislation requires to be the basis of the decision making are discussed in the Introduction.
-In addition, the reasons why the proposed action is believed by the Agency to be the best course of action shall be explained.	The rationale for the selection of solvent metal cleaners for control under the proposed standards is discussed in chapter 9, section 9.1. The Administrator's decision to control solvent metal cleaners under Federal standards and the reasons for regulating emissions from solvent metal cleaners under section III of the Clean Air Act is discussed in the Introduction.
3. Environmental impact of the proposed action.	
A. Primary impact Primary impacts are those that can be attributed directly to the action, such as reduced levels of specific pollutants brought about by a new standard and the physical changes that occur in the various media with this reduction.	The primary impacts on mass emissions and ambient air quality due to the alternative control systems is discussed in chapter 7. These impacts are summarized in Table 1-2, Matrix of Environmental and Economic Impact of the Alternative Standards, chapter 1, section 1.2.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT (continued)

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
B. Secondary impact Secondary impacts are indirect or induced impacts. For example, mandatory reduction of specific pollutants brought about by a new standard could result in the adoption of control technology that exacerbates another pollution problem and would be a secondary impact.	The secondary environmental impacts attributable to the alternative control systems are discussed in chapter 7. Secondary impacts on air quality are discussed in chapter 7. The anticipated impacts on energy requirements due to each alternative control system is discussed in chapter 7, section 7.4.
4. Other considerations.	
A. Adverse impacts which cannot be avoided should the proposal be implemented. Describe the kinds and magnitudes of adverse impacts which cannot be reduced in severity to an acceptable level or which can be reduced to an acceptable level but not eliminated. These may include air or water pollution, damage to ecological systems, reduction in economic activities, threats to health, or undesirable land use patterns. Remedial, protective, and mitigative measures which will be taken as part of the proposed action shall be identified.	A summary of the potential adverse environmental and economic impacts associated with the proposed standards and the alternatives that were considered is discussed in chapter 1, section 1.2 and chapter 7.
B. Relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity. Describe the extent to which the proposed action involves trade-offs between short-term losses or vice-versa and the extent to which the proposed action	The discussion of the use of man's environment is included in chapter 7, section 7.1. A discussion of the effects of emissions from solvent metal cleaners is included in chapter 9, section 9.1.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT (continued)

Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
forecloses future options. Special attention shall be given to effects which pose long-term risks to health or safety. In addition, the timing of the proposed action shall be explained and justified.	
C. Irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. Describe the extent to which the proposed action curtails the diversity and range of beneficial uses of the environment. For example, irreversible damage can result if a standard is not sufficiently stringent.	Irreversible and irretrievable commitments of resources are discussed in chapter 7, section 7.5.1.
-The analysis should be sufficiently detailed to reveal the Agency's comparative evaluation of the beneficial and adverse environmental, health, social and economic effects of the proposed action and each reasonable alternative.	A summary of the environmental and economic impacts associated with the proposed standards are presented in chapter 1, section 1.2. A detailed discussion of the environmental effects of each of the alternative control systems can be found in chapter 7. This chapter includes a discussion on the beneficial and adverse impacts on air, water, solid waste, energy, noise, radiation, and other environmental considerations. A detailed analysis of the costs and economic impacts associated with the proposed standards can be found in chapter 8.

APPENDIX C

EMISSION SOURCE TEST DATA

EPA has made an effort to gather all data and information currently available that describes the effectiveness of organic solvent cleaning emission control systems. These data are obtained within the docket and are summarized by this Appendix which discusses source test data on three discrete but related subject areas: first, degreaser controls and the overall emission reductions they can achieve; second, the effectiveness of carbon beds in adsorbing organics; and third, solvent concentrations found in steam condensate from regeneration of carbon beds.

C.1 DEGREASER CONTROLS

Emission test data have been developed from EPA source tests, and from tests conducted by organic solvent producers and degreaser manufacturers. Tests performed on OTVD and CD controlled with a variety of devices, are reported on in the appendices of the document, "Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations," written by D. W. Richards and K. S. Surprenant of the Dow Chemical Company, dated June, 1976. A table, summarizing the information in these reports is located in Appendix A (Table A-1) of the guideline document for solvent metal cleaning (CTG). Data on the effectiveness of various degreaser controls have also been developed by PEDCo Environmental under contract to EPA's Industrial Environmental Research Laboratory in Cincinnati, Ohio; by AutoSonics, Incorporated in Norristown, Pennsylvania; and by Allied Chemical Corporation in Buffalo, New York. Allied has requested that the tests conducted by them be kept confidential, pending publication of the results by the company. Emission tests conducted by AutoSonics and PEDCo can be found within the docket.

The emission reductions achieved by the various controls on OTVD ranged from 65 percent down to an actual increase in emissions of 8 percent (four of these controls were improperly designed or operated). This wide range exemplifies the need to consider the many factors affecting degreaser emissions when determining the effectiveness of controls. The size and design of degreasers, the application or type of work cleaned, and operating procedures all have large effects. These factors vary widely among existing degreasers making it difficult to pinpoint a single emission reduction which is representative of all like controls used throughout the country. No single test can be cited to define best available control technology. Rather, conclusions have been drawn through review of all the available test data with an understanding of the many factors which affected each test.

The docket also includes two series of tests conducted on cold cleaners by EPA. One test series investigated the effects of solvent agitation, solvent volatility, freeboard height and covers on evaporation losses. The second test series further investigated the effects of freeboard height on emissions, and quantified the amount of carry-out losses that could be expected from cold cleaners.

The tests on cold cleaners showed petroleum distillate emissions to be much less than the halogenated organic compound emissions. Also, emissions increased as draft velocities over the lip of the cold cleaners increased. Overall, the controls which have been tested and would be required by this NSPS are expected to reduce solvent emissions from cold cleaners by 80 percent.

C.2 CARBON BED EFFICIENCIES

This section summarizes data which support the performance specifications on exit gas streams from carbon adsorbers used to control emissions from degreasers. The data presented includes information obtained from testing carbon adsorbers on dry cleaning operations. These data are relevant and applicable because the compounds and inlet concentrations are similar to those found with carbon adsorbers on degreasers.

Table C-1 summarizes the results of tests on nine carbon adsorbers controlling a variety of organic compounds. The compounds adsorbed include trichloroethylene, perchloroethylene, 1,1,1-trichloroethane, and mixtures of several chlorinated and fluorinated methanes and ethanes. For each test, the inlet and exit concentrations are given along with the type of equipment the adsorber is controlling, the sampling technique used to develop the data, and remarks about the sample periods and adsorber operating conditions.

The organic concentrations in the adsorber exit streams ranged from 1 ppm to 45 ppm with one abnormally high value at 308 ppm, which is believed to reflect breakthrough of the carbon bed during this particular test. In general, the exit concentrations remained comparatively constant and at a low level (below 25 ppm) despite widely fluctuating inlet concentrations which ranged from 25 ppm to 6600 ppm.

Several of the tests (Nos. 1, 2, 7, and 8) yielded data on how the exit concentration varies with time throughout the adsorption/regeneration cycles. Review of these shows that, in general, the adsorber controls very well and uniformly with varying inlet concentrations until the bed nears saturation. At this point in time, known as breakthrough, the exit concentrations increase dramatically and the control efficiency of the carbon adsorber

Table C-1

TEST DATA ON COLLECTION EFFICIENCY OF CARBON ADSORPTION FOR SEVERAL ORGANIC COMPOUNDS

Test	Compound	Inlet Concentrations	Exit Concentrations	Adsorber Application	Measurement Technique	Remarks
1	Trichloroethylene[1]	120	4	Degreaser	Beckman Model 6800 THC Analyzer	The 5 samples are 2 to 3 hour averages over morning and afternoon periods. Results are supported by simultaneous GC analysis.
		90	12	Degreaser		
		-	22	Degreaser		
		115	45	Degreaser		
		70	8	Degreaser		
2	Trichloroethylene[2]	425	14	Degreaser	Scott Model 215 THC Analyzer	The 4 samples 4 to 6 hour averages on 4 consecutive mornings and are supported by simultaneous GC analysis.
		332	10	Degreaser		
		-	5	Degreaser		
		-	8	Degreaser		
3	Trichloroethylene[4]	25	2	Degreaser	Gas-Tech Halide Meter	The sample is a 3.5 average.
4	Trichloroethylene[4]	165	10	Degreaser	Gas-Tech Halide Meter	The sample is a 3 hour average. Both beds were regenerated during this period.
5	Trichloroethylene[5]	37 to 145 (range)	11	Degreaser	Gas-Tech Halide Meter	The exit concentration an 8-hour average. Both beds were regenerated during this period.
6.	1,1,1-Trichloroethane[6]	148	18	Degreaser	Carbon tube adsorption extraction; then, GC analysis of extract.	Samples are 2 to 4 hour averages taken with and without parts being degreased.
		4745	307**	Degreaser		

(continued)

Table C-1 (cont'd)

Test	Compound	Inlet Concentrations	Exit Concentrations	Adsorber Application	Measurement Technique	Remarks
7	Perchloroethylene[7]	542 748 617	31 24 17	Dry Cleaner Dry Cleaner Dry Cleaner	GC/FID; integrated bag samples	Samples are 6 hour averages which do not include desorption cycles.
8	Perchloroethylene[8]	5300 6300 6500	31 24 16	Dry Cleaner Dry Cleaner Dry Cleaner	GC/FID; integrated bag samples.	Samples are 1 to 2 hour averages which do not include desorption cycles.
9	Mixed Organics[9]	200 - 500 500 3200 - 6600 45	< 10 < 5 3-6 < 1	Laboratory tests on carbon column.	Detectable limit = 5 ppm = 1 ppm = 1 ppm	Exit concentrations are prior to breakthrough. Compounds include: CH_2Cl_2; CH_3Cl & CCl_2F_2; and $C_2Cl_2F_4$.

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*ppm by volume, expressed as the compound being controlled.

**the carbon bed in this test was believed to have reached breakthrough during the sampling period.

drops to zero. Existence of this breakthrough phenomenon with some adsorbers, along with data on other adsorbers which maintain continuous flow concentrations throughout periods which include regeneration cycles, show the importance of correctly timing the adsorption/regeneration cycles. In conclusion, the data indicate that when correctly designed and properly operated, carbon adsorbers can continuously reduce a wide range of inlet concentrations to below 25 ppm.

C.3 SOLVENT CONCENTRATIONS IN STEAM CONDENSATE

This section summarizes the available test data on the amount of residual solvent present in condensate from steam regenerated carbon beds. All data are developed from adsorbers controlling emissions of perchloroethylene from dry cleaning operations, but would be applicable to carbon adsorbers controlling degreasers.

Table C-2 lists the perchloroethylene concentrations found in sewered condensate from adsorbers in three different locations. Also shown are remarks to clarify the data presented. Results show average concentrations of perchloroethylene in the condensate over complete regeneration cycles range from 38 to 113 ppm. Instantaneous values ranged from nearly 1000 ppm early in the desorption cycle, to zero near the end of the cycle.

Two general observations can be made from reviewing the data. First, the solvent concentration in the condensate is initially quite high but it drops off quickly. Second, in all cases the average concentration over the regeneration cycle was less than handbook values of the solubility of perchloroethylene in water (approximately 1000 ppm).

Table C-2

SOLVENT CONCENTRATIONS IN STEAM CONDENSATE FROM REGENERATION OF CARBON BEDS

Test	Compound	Concentration* in Condensate	Remarks
1	Perchloroethylene[10]	1010 62 6	Instantaneous samples in the beginning, middle, and end of a 5-hour desorption cycle.
2	Perchloroethylene[11]	113 38 66 65	Averages over about 1 hour desorption cycles.
3	Perchloroethylene[12]	102 100 71	Averages over about 1/2 to 3/4 hour desorption cycle.

* ppm by volume expressed as perchloroethylene.

References

1. Scheil, George W., Midwest Research Institute, Air Pollution Emission Test, "Source Test Trichloroethylene Degreaser Adsorber," Report No. 76-DEG-1, prepared for the U. S. Environmental Protection Agency, Research Triangle Park, North Carlina, February 11, 1976.

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APPENDIX D

EMISSION MEASUREMENT AND CONTINUOUS MONITORING

D.1 EMISSION MEASUREMENT METHODS

The primary method used to gather emission data has been the integrated bag sampling procedure followed by gas chromatographic/flame ionization detector analysis. Appendix A, 40 CFR Part 60, EPA Method 23: Determination of Halogenated Organics from Stationary Sources," describes this approach. For this method, the integrated bag sampling technique was chosen over charcoal adsorption tubes for two reasons: (1) less uncertainty about sample recovery efficiency, and (2) only one sample portion of analyze per sample run.

This method was written because an initial EPA funded study on halogenated hydrocarbon monitoring revealed areas where improvements in the bag sampling technique were needed. In particular, leaking bags and bag containers were cited as probable causes of poor correlation between integrated and grab samples taken at an emission site. In light of these findings, more rigorous leak check procedures were incorporated. The first EPA test with the improved method utilized both integrated bag and grab sampling techniques as forms of quality control. For the three days during which tests were made, very good correlation between the two techniques was obtained.

D.2 MONITORING SYSTEMS AND DEVICES

There are several types of portable, self-contained instruments currently available for emission monitoring in organic solvent cleaning facilities. The principles of operation are catalytic-oxidation, flame ionization, photoionization, and infrared energy absorption. All four types of detection will respond to practically all types of organic materials, although the relative responses to the different types will vary.

For halogenated solvent operations where a single compound predominates the instruments can be calibrated with the compound and the results will be on that basis. Examples of some manufacturers' reported ranges for perchloroethylene are: (1) catalytic-oxidation, 27-1300 ppmv; (2) flame ionization, 2-20,000 ppmv; and (3) infrared, 0.5-200 ppm +, depending on configuration.

The cost of a monitoring instrument ranges from about $1000 to $5000, depending on the detection principle, operating features, and required accessories associated with the different instrument types and vendors. An EPA contractor examined several less expensive systems at a drycleaning plant in New York and determined them to be inadequate because of erratic responses.

D.3 PERFORMANCE TEST METHODS

If it is necessary to conduct an emission test for halogenated compounds on the adsorber vent, then Method 23: "Determination of Halogenated Organics from Stationary Sources" is recommended as the performance test method.

In the final draft of Method 23, further leak checks were added as precautions against erroneous data. These additions were suggested by an EPA contractor that was studying the vinyl chloride test method. No particular problems with the use of Method 23 should occur, provided that strict adherence is made to the leak check procedures. For non-halogenated VOC emissions, Method 25: "Determiantion of Total Gaseous Non-Methane Organic Emissions as Carbon: Manual Sampling and Analysis Procedures: should be the performance test method.

The costs for conducting either a Method 23 or a Method 25 emission test in triplicate by a source testing contractor will depend on the length of the carbon adsorber cycle and the distance to be travelled by testing personnel. They are estimated at $2000 to $5000 for a single unit installation. Testing costs per unit would be lower if several units at a single site were tested.

APPENDIX E. ENFORCEMENT ASPECTS

The selected format for the proposed New Source Performance Standard is a design/equipment/work practice/operational standard. The basis for this selection is described in Chapter 9.4. Three options were considered in determining the enforcement requirements for the proposed standard:

- A combination of design and equipment specifications by degreaser type and size; periodic inspections of work line and operational practices; prominent display of specified operational procedures; solvent consumption record-keeping; and maintenance and training requirements for degreaser users.
- A combination of controls applicable to all degreasers regardless of the types and sizes of degreasers; recordkeeping (e.g., solvent used, reporting all spills and leaks, and ultimate disposal); maintenance for all leaks in excess of a specified amount; daily inspection of all degreasing equipment by plant personnel; periodic reports to EPA detailing the above; and routine EPA inspection.
- A periodic inspection to check operational practices.

The first option combines design, equipment, work practice, and operational standards to permit the most efficient emission control and enforceability. Under this option, a number of measures will have to be taken by users of degreasers to comply with the proposed standards; these include:

- Purchase of degreasing equipment which meets the design and equipment standards.
- Implementation of proper work practice to minimize emission. This may include preventative maintenance programs, proper display of warning signs and work procedure instructions,

regular inspections, and start-up, shut-down and emergency procedures.

- Record keeping and reporting, certification of training of degreaser operators, and acquiring equipment operating manual(s) and making them available to operators.

This option also indirectly provides an incentive to the manufacturers to design to the specified standards. The types of control equipment specified in the regulations are currently in use and are commercially available.

The second option would specify design and equipment requirements for all types of degreasers. Since degreasers are mostly used in small shops, e.g., garages, the proposed equipment and work practice standards may represent an unreasonable burden on the users of degreasers. Small businesses generally do not have the capability nor the resources to comply with these requirements. Enforcement of these practices would require EPA to process detailed routine reports and to inspect the operations routinely. EPA lacks the resources necessary to implement this type of enforcement procedure. An unreasonable requirement may lead to litigation which would effectively postpone implementation of any control measures for degreasers.

The third option does not provide sufficient enforcement to guarantee the implementation of a design/equipment/work practice/ operational standard. There is no written certification that the specified equipment is being used. There is no assurance that the workers are properly trained or that the equipment is routinely maintained. Thus, there would be no assurance of compliance with the key elements of the standard.

In summary, the second option is excessive because it incorporates requirements beyond those needed to insure compliance with the standard while the third option is inadequate because it does not provide means to insure compliance with the standard. The first option--which is a combination design, equipment, work practice, and operational standard--offers the best enforcement mechanism to satisfy all objectives of the proposed standard. This option therefore will provide the best emission control and enforceability.

Enforcement of the proposed regulation will be accomplished by means of EPA on-site inspections of equipment, work practices, and records; by maintaining certification statements for all affected facilities; and by maintaining and routinely examining the quarterly reports that will be submitted in accordance with the regulation. Reports of inspection should be submitted on special forms suitable for automatic data processing, and they should be filed with the EPA Regional Office for the region in which the inspection was made. Inspection reports should be processed expeditiously; they should be reviewed regularly in order to concentrate enforcement activities on facilities with greatest need.

Violations must be adjudicated immediately in order to prevent the intent of the regulation from being negated. Violations detected during an inspection must be flagged on the inspection report. In the case of each violation that directly affects solvent emissions, as for example failure to use a prescribed control device, the owner of the facility must be notified of the violation and the period of time in which it must be corrected. Action should be taken to halt the degreasing operation if the violation is not corrected within the specified time. Violations of record keeping and of other similar provisions in the regulation that do not affect emissions should be handled by routine administrative procedures.

APPENDIX F. ECONOMICS

F.1 MANUFACTURING DEGREASING...SIC CODES 25, 33-39

For the purposes of this study it was necessary to estimate the numbers of cold cleaners, open top vapor degreasers, and closed conveyor degreasers located in selected 3-digit SIC code manufacturing industries. These estimates were constructed by adapting, extrapolating and combining the data on degreasing which exists from previous studies. Although no single work is sufficient for this purpose, these studies combined provided the information necessary for basic estimates of numbers of degreasers.

In a study performed for the Environmental Protection Agency (Richards and Surprenant, 1976),[1] researchers at the Dow Chemical Company estimated the number of degreaser systems in 2-digit SIC code manufacturing industries for 1974. The first step in the estimation procedure was to allocate those degreasers among the component 3-digit SIC industries. This allocation, which was based on the Eureka Laboratories estimates of organic solvent emissions in California (Leung et al., 1976)[2] is described below.

The Eureka study determined levels of organic solvent emissions (tons per day) for various 3-digit SIC code industries in California in 1976 (X_c). These California figures were converted to national figures (X_n) through the multiplication of each by the ratio of an industry's 1976 nationwide value of shipments (q_n) to its 1976 value of shipments from California (q_c). In each case, the value of shipments used was taken from the Annual Survey of Manufacturers, 1976.[3] When such figures were unavailable (for California), the ratio of the number of firms in the U.S. for 1972 to the number of firms in California in 1972, taken from the 1972 Census of Manufacturers,[4] was used to estimate X_n. A total emission level was calculated for each 2-digit SIC code

code industry by summing emissions from the component 3-digit industries. The share of each 3-digit industry's emissions in the appropriate 2-digit industry emission total was then calculated. Both total emissions and shares are presented in Table F1-1.

Since solvent emissions are produced by the degreasing process, it was assumed that degreasing systems are distributed in the same manner as solvent emissions. Accordingly, the emission shares calculated above for 3-digit industries were applied to DOW's 2-digit industry estimates of total degreasing systems to produce estimated numbers of degreasing systems within 3-digit SIC code industries. For closed conveyor and open top vapor degreasers this application was straightforward: a multiplication of the 2-digit SIC totals by the 3-digit SIC share estimates. For cold cleaners, further explanation and adjustment are required.

The Dow survey estimated numbers of degreasing systems in manufacturing operations employing twenty or more workers. This captured most, if not all of the closed conveyor and open top vapor degreasers, since such systems are commonly found in large enterprises. But there are many cold cleaning systems located in plants with twenty or fewer employees for which an accounting must be made. Accordingly, it was assumed that, for each 3-digit SIC code industry, a plant with twenty or fewer workers is just as likely to have a cold cleaner as is a plant with more than twenty workers. The *1972 Census of Manufactures* provides data, for each 3-digit SIC industry, on the number of establishments with more than twenty employees and the number with twenty or fewer. For each 3-digit industry, the fraction of all plants with more than twenty workers having degreasers was calculated. This fraction was then applied to the number of establishments with twenty or fewer workers, in order to estimate the number of cold cleaning systems in such plants. The numbers

TABLE F1-1. ESTIMATED NATIONAL ORGANIC SOLVENT EMISSIONS
BY DIFFERENT MANUFACTURING INDUSTRY

SIC	Industry	Emissions (Tons per Day)	Shares (3-Digit/2-Digit Total)
25	Metal Furniture	4.13	
254	Partitions and Fixtures	3.26	0.789
259	Misc. Furniture and Fixtures	0.87	0.211
33	Primary Metals	12.26	
332	Iron and Steel Foundries	0.93	0.076
335	Nonferrous Rolling and Drawing	2.11	0.172
336	Nonferrous Foundries	0.76	0.062
339	Misc. Primary Metal Products	3.46	0.690
34	Fabricated Products	106.09	
342	Cutlery, Hand Tools, and Hardware	26.87	0.253
343	Plumbing and Heating (except Electric	4.74	0.045
344	Fabricated Structural Metal Products	17.92	0.169
345	Screw Machine Products, Bolts, etc.	4.05	0.038
346	Metal Gorgings and Stampings	5.33	0.050
347	Metal Services	26.62	0.251
348	Ordnance and Accessories	0.11	0.001
349	Misc. Fabricated Metal Products	20.45	0.193
35	Non-Electric Machinery	105.41	
351	Engines and Turbines	0.79	0.007
352	Farm and Garden Machinery	6.26	0.059
353	Construction and Related Machinery	9.50	0.090
354	Metalworking Machinery	13.35	0.127
355	Special Industrial Machinery	0.90	0.009
356	General Industrial Machinery	42.32	0.401
357	Office and Computing Machines	4.69	0.044
358	Refrigeration and Service Machinery	3.92	0.037
359	Misc. Machinery, except Electrical	23.68	0.225
36	Electric Equipment	40.26	
361	Electric Distributing Equipment	4.87	0.121
362	Electrical Industrial Apparatus	1.49	0.037
364	Electric Lighting and Wiring Equip.	13.49	0.335
366	Communication Equipment	13.12	0.326
367	Electronic Components and Accessories	6.91	0.172
369	Misc. Electrical Equip. and Supplies	0.38	0.009
37	Transportation Equipment	218.58	
371	Motor Vehicles and Equipment	35.52	0.163
372	Aircraft and Parts	172.03	0.787
376	Guided Missiles, Space Vehicles, Parts	10.98	0.050
379	Misc. Transportation Equipment	0.05	---
38	Instruments and Clocks	1.90	
381	Engineering and Scientific Instruments	0.28	0.147
382	Measuring and Controlling Devices	1.62	0.853
	Total	488.63	

of cold cleaners in small plants were added to the numbers of cold cleaners in large plants to produce a first estimate of cold cleaning systems in manufacturing.

In fact, all of the aforementioned estimates of numbers of degreasers are first estimates only. Several expansions and corrections must be made in order to generate the best possible estimates. First, the estimates constructed thus far for cold cleaners are for the numbers of cold cleaning systems, not the component cold cleaners, per se. Consequently, these estimates are used mainly to describe the distribution of cold cleaners within the affected industries rather than to measure the total numbers of cold cleaners. Independent information from the EPA [U.S. Environmental Protection Agency, Nov., 1977][5] indicates that there were approximately 340,000 cold cleaners being used in manufacturing processes in 1974. This total is distributed among the appropriate 3-digit SIC code industries in accordance with the distribution of cold cleaning systems described above.

Second, a comparison of Dow's estimates for closed conveyor and open top vapor degreasers with EPA estimates indicates that the Dow research underestimates the number of each kind of cleaner. Again, the estimates constructed above are considered to represent accurately the distributions of such systems, if not the total numbers. In order to produce better approximations, corrections factors of 1.373 for open top vapor degreasers and 1.323 for closed conveyor degreasers are applied to the estimated numbers of degreaser in 3-digit SIC code industries.

Next, the estimated numbers of degreasers for 1974 are updated to produce estimates for 1976. The numbers of degreasers are assumed to increase approximately in the same proportion as productive capacity. Separate expansion factors are estimated for each 3-digit SIC code industry. Each factor was calculated by dividing real investment in plant and equipment in 1975 and 1976 by the value of plant and equipment in 1976, with the requisite information coming from the Annual Survey of Manufacturers, 1976.

Lastly, these estimate of numbers of degreasers are compared with independent information on such numbers in 1976. EPA estimates for the numbers of degreasers in 1974 are combined with industry estimates for the numbers of vapor degreasing systems produced and cold between 1974 and 1976, to generate estimates of the numbers of closed conveyor and open top vapor degreasing systems in place in 1976. Such figures indicate that there should be at least 27,000 open top vapor degreasing systems and at least 4200 closed conveyor systems in manufacturing in 1976. Since our estimate for closed systems (4492) is only moderately greater than 4200, it is regarded as acceptable. For open top vapor degreasing systems, the original estimate (25,604) is too low. Since the distribution of such systems within the 3-digit industries is considered to be representative, the number of open top vapor degreaers within each industry is inflated through multiplication by a factor of (27,000/-25,604) or 1.0545. The resulting estimate of numbers of degreasers of all kinds are presented in Table F1-2.

For the purposes of our study, it is necessary, also, to allocate these degreasing systems across geographic regions. Since there is no direct information on degreasers by geograhic area, it is assumed that degreasers are distributed in the same manner as the manufacture of the goods in whose production they are used. The 1972 Census of Manufacturers provides data on the regional values of shipments within many of the 3-digit industries considered here. For those industries, the total number of degreasers of each type is allocated among regions on the same basis as the value of shipments. In 3-digit industries for which information on the regional values of shipments is unavailable, data on the numbers of plants in the various regions is used. For those

TABLE F1-2. ESTIMATED NUMBERS OF DEGREASERS BY MANUFACTURING INDUSTRY FOR 1976

SIC	Industry	Cold Cleaners	Open Top Vapor Degreasers	Closed Conveyor Degreasers
25	Metal Furniture	9,421	460	153
254	Partitions and Fixtures	6,156	351	117
259	Misc. Furniture and Fixtures	3,265	109	36
33	Primary Metals	18,011	1,773	442
332	Iron and Steel Foundries	1,992	137	34
335	Nonferrous Rolling and Drawing	2,246	277	70
336	Nonferrous Foundries	4,058	105	25
339	Misc. Primary Metal Products	9,715	1,254	313
34	Fabricated Products	86,408	4,486	1,088
342	Cutlery, Hand Tools, and Hardware	11,891	1,152	280
343	Plumbing and Heating (except Electric	2,772	205	49
344	Fabricated Structural Metal Products	25,131	771	187
345	Screw Machine Products, Bolts, etc.	5,409	160	39
346	Metal Gorgings and Stampings	5,892	205	50
347	Metal Services	19,157	1,124	273
348	Ordnance and Accessories	132	5	1
349	Misc. Fabricated Metal Products	16,024	864	209
35	Non-Electric Machinery	189,693	4,748	1,014
351	Engines and Turbines	792	33	6
352	Farm and Garden Machinery	8,238	304	65
353	Construction and Related Machinery	11,089	451	96
354	Metalworking Machinery	38,152	569	122
355	Special Industrial Machinery	10,467	41	9
356	General Industrial Machinery	30,734	1,876	402
357	Office and Computing Machines	4,589	220	47
358	Refrigeration and Service Machinery	6,085	169	35
359	Misc. Machinery, except Electrical	79,547	1,085	232
36	Electric Equipment	45,542	7,587	996
361	Electric Distributing Equipment	3,945	871	115
362	Electrical Industrial Apparatus	4,138	279	36
364	Electric Lighting and Wiring Equip.	10,935	2,465	324
366	Communication Equipment	11,339	2,539	333
367	Electronic Components and Accessories	10,196	1,362	178
369	Misc. Electrical Equip. and Supplies	4,989	71	10
37	Transportation Equipment	27,985	3,587	507
371	Motor Vehicles and Equipment	10,944	630	89
372	Aircraft and Parts	11,967	2,779	393
376	Guided Missiles, Space Vehicles, Parts	716	178	25
379	Misc. Transportation Equipment	4,358	0	0
38	Instruments and Clocks	23,883	3,744	219
381	Engineering and Scientific Instruments	6,086	550	32
382	Measuring and Controlling Devices	17,797	3,194	187
39	Miscellaneous Industry	15,936	614	73
	TOTAL	416,879	26,999	4,492

industries, degreasers are assumed to be distributed in the same manner as manufacturing establishments. The resulting geographic distribution of cold cleaners is presented in Table F1-3.

Analogous estimates for open top and closed conveyor vapor degreasers are found in Table F1-4 and Table F1-5, respectively.

Table F1-3. NUMBERS OF COLD CLEANERS BY GEOGRAPHIC LOCATION*.

SIC	Industry	North East	Mid Atlantic	East North-Central	West North-Central	South Atlantic	East South-Central	West South-Central	Mountain	Pacific	TOTAL
25	Metal Furniture	432	2,001	3,090	688	1,029	433	482	156	1,110	9,421
254	Partitions and Fixtures	252	1,459	1,908	492	591	283	351	117	702	6,155
259	Misc. Furniture and Fixtures	180	542	1,182	196	438	150	131	39	408	3,266
33	Primary Metals	1,460	3,472	7,977	853	685	1,107	687	259	1,614	18,114
332	Iron and Steel Foundries	46	271	1,128	82	135	131	84	18	98	1,993
335	Nonferrous Rolling and Drawing	272	492	640	99	236	234	81	70	144	2,268
336	Nonferrous Foundries	170	747	2,041	264	61	227	114	16	430	4,070
339	Misc. Primary Metal Products	972	1,962	4,168	408	253	515	408	155	942	9,783
34	Fabricated Products	6,495	15,041	33,603	4,675	6,494	4,263	5,895	1,131	8,881	86,478
342	Cutlery, Hand Tools, and Hardware	1,926	1,986	5,351	464	476	369	131	83	1,153	11,939
343	Plumbing and Heating (except Electric)	97	480	1,258	116	222	225	91	0	277	2,766
344	Fabricated Structural Metal Products	1,030	4,423	6,283	1,910	3,518	1,809	2,915	628	2,588	25,104
345	Screw Machine Products, Bolts, etc.	579	882	2,959	130	146	162	65	43	449	5,415
346	Metal Gorgings and Stampings	253	778	4,207	106	124	147	77	12	200	5,904
347	Metal Services	1,552	3,448	7,529	900	1,092	441	1,207	153	2,854	19,176
348	Ordnance and Accessories	16	16	23	39	3	4	15	4	14	134
349	Misc. Fabricated Metal Products	1,042	3,028	5,993	1,010	913	1,106	1,394	208	1,346	16,040
35	Non-Electric Machinery	14,683	34,538	71,744	15,988	12,270	7,955	10,435	3,349	20,446	191,408
351	Engines and Turbines	116	155	410	18	36	2	2	2	110	851
352	Farm and Garden Machinery	16	330	3,633	2,661	379	766	181	74	198	8,238
353	Construction and Related Machinery	100	1,308	5,445	1,131	399	233	1,464	177	810	11,067
354	Metalworking Machinery	4,502	5,914	21,212	1,641	2,060	534	496	153	1,793	38,305
355	Special Industrial Machinery	1,476	1,800	3,182	398	1,800	324	335	105	1,371	10,791
356	General Industrial Machinery	2,705	7,345	12,324	1,967	1,322	1,137	1,352	369	2,213	30,734
357	Office and Computing Machines	647	982	519	496	285	422	78	395	821	4,645
358	Refrigeration and Service Machinery	110	1,351	2,428	596	262	560	481	6	243	6,037
359	Misc. Machinery, except Electrical	5,011	15,353	22,591	7,080	5,727	3,977	6,046	2,068	12,887	80,740
36	Electric Equipment	4,357	11,899	11,842	2,595	4,307	2,041	2,473	872	5,195	45,581
361	Electric Distributing Equipment	414	1,112	935	312	469	300	142	12	252	3,948
362	Electrical Industrial Apparatus	261	881	1,697	194	389	290	244	17	170	4,143
364	Electric Lighting and Wiring Equip.	1,170	3,084	3,270	503	864	831	306	66	831	10,925
366	Communica[illegible]quipment	1,066	2,426	2,075	601	1,463	317	964	329	2,098	11,339
367	Electronic Components and Accessories	1,152	3,742	1,550	316	683	163	632	418	1,580	10,236
369	Misc. Electrical Equip. and Supplies	294	654	2,315	669	439	140	185	30	264	4,990

Table F1-3 (continued)

SIC	Industry	North East	Mid Atlantic	East North-Central	West North-Central	South Atlantic	East South-Central	West South-Central	Mountain	Pacific	TOTAL
37	Transportation Equipment	1,785	2,262	9,688	3,020	2,112	623	1,788	470	6,456	28,204
371	Motor Vehicles and Equipment	109	930	6,621	1,029	952	328	197	22	755	10,943
372	Aircraft and Parts	1,568	981	1,568	1,113	814	132	1197	215	4,368	11,956
376	Guided Missiles, Space Vehicles, Parts	30	59	4	50	54	19	15	59	370	660
379	Misc. Transportation Equipment	78	292	1,495	828	292	144	379	174	963	4,645
38	Instruments and Clocks	2,963	5,188	6,193	1,520	993	405	640	978	5,047	23,927
381	Engineering and Scientific Instruments	578	1,308	1,637	310	335	85	213	213	1,345	6,024
382	Measuring and Controlling Devices	2,385	3,880	4,556	1,210	658	320	427	765	3,702	17,903
39	Miscellaneous Industry	2,454	5,450	3,171	813	1,052	765	574	239	1,418	15,936
	Total Manufacturing	34,629	79,851	147,308	30,152	28,942	17,592	22,974	7,454	50,167	419,069
401	Railroads - Maintenance†	-	-	-	-	-	-	-	-	-	1,161
458	Air Transport - Maintenance	1,369	2,915	5,805	5,203	4,368	2,288	5,641	3,404	5,167	36,160
753	Auto Repair§	22,979	58,733	87,471	48,224	76,566	33,757	58,637	26,519	55,141	468,027
	Total Service	24,348	61,648	93,276	53,427	80,934	36,045	64,278	29,923	60,308	505,348
	General Industrial Usage¶	17,179	56,004	94,829	27,487	42,948	21,302	35,733	8,590	39,512	343,584
	TOTAL	76,156	197,503	335,413	111,066	152,824	74,939	122,985	45,967	149,987	1,268,001

*As a result of rounding, numbers may differ slightly from those in the previous tables.

†The geographic distribution of railroad maintenance is not available.

§Data for auto repairs is actually for 1975, but represents as close an estimate for 1976 as is possible.

¶Represents degreasers used for general internal maintenance throughout the economy.

Table F1-4. NUMBERS OF OPEN TOP VAPOR DEGREASERS BY GEOGRAPHIC LOCATION*.

SIC	Industry	North East	Mid Atlantic	East North-Central	West North-Central	South Atlantic	East South-Central	West South-Central	Mountain	Pacific	TOTAL
25	Metal Furniture	20	101	148	35	49	21	24	8	54	460
254	Partitions and Fixtures	14	83	109	28	34	16	20	7	40	351
259	Misc. Furniture and Fixtures	6	18	39	7	15	5	4	1	14	109
33	Primary Metals	166	352	748	78	73	110	72	30	158	1,787
332	Iron and Steel Foundries	3	19	78	6	9	9	6	1	7	138
335	Nonferrous Rolling and Drawing	34	61	79	12	29	29	10	9	18	281
336	Nonferrous Foundries	4	19	53	7	2	6	3	0	11	105
339	Misc. Primary Metal Products	125	253	538	53	33	66	53	20	122	1,263
34	Fabricated Products	400	782	1,804	229	291	205	261	48	472	4,492
342	Cutlery, Hand Tools, and Hardware	187	192	518	45	46	36	13	8	112	1,157
343	Plumbing and Heating (except Electric)	7	35	93	9	16	17	7	0	20	204
344	Fabricated Structural Metal Products	32	136	193	59	108	56	89	19	79	771
345	Screw Machine Products, Bolts, etc.	17	26	88	4	4	5	2	1	13	160
346	Metal Gorgings and Stampings	9	27	146	4	4	5	3	0	7	205
347	Metal Services	91	202	442	53	64	26	71	9	167	1,125
348	Ordnance and Accessories	1	1	1	1	0	0	1	0	1	6
349	Misc. Fabricated Metal Products	56	163	323	54	49	60	75	11	73	864
35	Non-Electric Machinery	350	908	1,852	429	250	205	257	82	434	4,767
351	Engines and Turbines	5	6	17	1	2	0	0	0	5	36
352	Farm and Garden Machinery	1	12	134	98	14	28	7	3	7	304
353	Construction and Related Machinery	4	53	221	46	16	9	60	7	33	449
354	Metalworking Machinery	67	88	316	24	31	8	7	2	27	570
355	Special Industrial Machinery	6	7	12	2	7	1	1	0	5	41
356	General Industrial Machinery	165	448	752	120	81	69	83	23	135	1,876
357	Office and Computing Machines	31	47	25	24	14	20	4	19	39	223
358	Refrigeration and Service Machinery	3	38	67	17	7	16	13	0	7	168
359	Misc. Machinery, except Electrical	68	209	308	97	78	54	82	28	176	1,100
36	Electric Equipment	770	2,052	1,762	382	750	368	419	149	939	7,591
361	Electric Distributing Equipment	91	246	206	69	104	66	31	3	56	872
362	Electrical Industrial Apparatus	18	59	114	13	26	20	16	1	11	278
364	Electric Lighting and Wiring Equip.	264	695	737	113	195	187	69	15	187	2,462
366	Communication Equipment	239	543	465	135	328	71	216	74	470	2,541
367	Electronic Components and Accessories	154	500	207	42	91	22	84	56	211	1,367
369	Misc. Electrical Equip. and Supplies	4	9	33	10	6	2	3	0	4	71

Table F1-4 (continued)

SIC	Industry	North East	Mid Atlantic	East North-Central	West North-Central	South Atlantic	East South-Central	West South-Central	Mountain	Pacific	TOTAL
37	Transportation Equipment	377	297	746	329	258	55	293	66	1,149	3,570
371	Motor Vehicles and Equipment	6	54	381	59	55	19	11	1	43	629
372	Aircraft and Parts	364	228	364	258	189	31	278	50	1,014	2,776
376	Guided Missiles, Space Vehicles, Parts	7	15	1	12	14	5	4	15	92	165
379	Misc. Transportation Equipment	0	0	0	0	0	0	0	0	0	0
38	Instruments and Clocks	480	814	966	245	148	65	96	156	786	3,756
381	Engineering and Scientific Instruments	52	118	148	28	30	8	19	19	122	544
382	Measuring and Controlling Devices	428	696	818	217	118	57	77	137	664	3,212
39	Miscellaneous Industry	95	210	122	31	41	29	22	9	55	614
	Total Manufacturing	2,658	5,516	8,148	1,758	1,860	1,058	1,444	548	4,047	27,037
401	Railroads - Maintenance[†]	-	-	-	-	-	-	-	-	-	61
458	Air Transport - Maintenance	120	228	498	483	450	257	529	315	399	3,279
	Total Service	120	228	498	483	450	257	529	315	399	3,340
	TOTAL	2,778	5,744	8,646	2,241	2,310	1,315	1,973	863	4,446	30,377

[*] As a result of rounding, numbers may differ slightly from the previous table.

[†] The geographic distribution of railroad maintenance is not available.

Table F1-5. NUMBERS OF CONVEYORIZED VAPOR DEGREASERS BY GEOGRAPHIC LOCATION*.

		North East	Mid Atlantic	East North-Central	West North-Central	South Atlantic	East South-Central	West South-Central	Mountain	Pacific	TOTAL
25	Metal Furniture	7	34	49	11	16	7	8	2	17	151
254	Partitions and Fixtures	5	28	36	9	11	5	7	2	13	116
259	Misc. Furniture and Fixtures	2	6	13	2	5	2	1	0	4	35
33	Primary Metals	41	88	186	19	17	27	18	7	39	442
332	Iron and Steel Foundries	1	5	19	1	2	2	1	0	2	33
335	Nonferrous Rolling and Drawing	8	15	20	3	7	7	3	2	4	69
336	Nonferrous Foundries	1	5	13	2	0	1	1	0	3	26
339	Misc. Primary Metal Products	31	63	134	13	8	17	13	5	30	314
34	Fabricated Products	97	190	437	55	71	48	63	12	115	1088
342	Cutlery, Hand Tools, and Hardware	45	47	126	11	11	9	3	2	27	281
343	Plumbing and Heating (except Electric)	2	8	22	2	4	4	2	0	5	49
344	Fabricated Structural Metal Products	8	33	47	14	26	13	22	5	19	187
345	Screw Machine Products, Bolts, etc.	4	6	21	1	1	1	0	0	3	37
346	Metal Gorgings and Stampings	2	7	36	1	1	1	1	0	2	51
347	Metal Services	22	49	107	13	16	6	17	2	41	273
348	Ordnance and Accessories	0	0	0	0	0	0	0	0	0	0
349	Misc. Fabricated Metal Products	14	40	78	13	12	14	18	3	18	210
35	Non-Electric Machinery	75	195	396	91	54	44	56	18	93	1022
351	Engines and Turbines	1	1	3	0	0	0	0	0	1	6
352	Farm and Garden Machinery	0	3	29	21	3	6	1	1	2	66
353	Construction and Related Machinery	1	11	47	10	3	2	13	2	7	96
354	Metalworking Machinery	14	19	68	5	7	2	2	0	6	123
355	Special Industrial Machinery	1	2	3	0	2	0	0	0	1	9
356	General Industrial Machinery	35	96	161	26	17	15	18	5	29	402
357	Office and Computing Machines	7	10	5	5	3	4	1	4	8	47
358	Refrigeration and Service Machinery	1	8	14	3	2	3	3	0	1	35
359	Misc. Machinery, except Electrical	15	45	66	21	17	12	18	6	38	238
36	Electric Equipment	101	268	232	51	99	49	54	19	124	997
361	Electric Distributing Equipment	12	32	27	9	14	9	4	0	7	114
362	Electrical Industrial Apparatus	2	8	15	2	3	3	2	0	1	36
364	Electric Lighting and Wiring Equip.	35	91	97	15	26	25	9	2	25	325
366	Communication Equipment	31	71	61	18	43	9	28	10	62	333
367	Electronic Components and Accessories	20	65	27	6	12	3	11	7	28	179
369	Misc. Electrical Equip. and Supplies	1	1	5	1	1	0	0	0	1	10

Table F1-5 (continued)

	North East	Mid Atlantic	East North-Central	West North-Central	South Atlantic	East South-Central	West South-Central	Mountain	Pacific	TOTAL
37 Transportation Equipment	53	42	105	47	37	8	42	9	162	505
371 Motor Vehicles and Equipment	1	8	54	8	8	3	2	0	6	90
372 Aircraft and Parts	51	32	51	37	27	4	39	7	143	391
376 Guided Missiles, Space Vehicles, Parts	1	2	0	2	2	1	1	2	13	24
379 Misc. Transportation Equipment	0	0	0	0	0	0	0	0	0	0
38 Instruments and Clocks	28	48	57	15	9	3	5	9	46	220
381 Engineering and Scientific Instruments	3	7	9	2	2	0	1	1	7	32
382 Measuring and Controlling Devices	25	41	48	13	7	3	4	8	39	188
39 Miscellaneous Industry	11	25	15	4	5	4	3	1	6	74
Total Manufacturing	413	890	1477	293	308	190	249	77	602	4499

*As a result of rounding, numbers may differ slightly from those on the previous tables.

F.2 MAINTENANCE DEGREASING OF RAILROAD STOCK

A study of 4 railroad maintenance depots in California revealed that each month 505 gallons of chlorinated solvents and 1184 gallons of petroleum solvents, alcohols and ketones were used in conjunction with vapor degreasers and cold cleaners to maintain 4432 locomotives (Leung et al., 1978). It is assumed that the non-chlorinated solvents were used in cold cleaners of average size and that the chlorinated solvents were used in open top vapor degreasers. Utilizing the EPA estimates of average annual emissions for maintenance for cold cleaners (6.5 gallons per unit per month) (EPA, 1977), and industry estimates of solvent usage in open top degreasers* (50 gallons per unit per month), the California plants are assumed to operate 190 cold cleaners and 10 vapor degreasers. In 1976 the total number of locomotives in the U. S. A. was 27,609. Multiplying the estimated number of degreasers in the 4 California plants by 27,609/4,432 (=6.11) an estimate of total number of degreasers used in railroad maintenance is obtained (1161 cold cleaners and 61 open top vapor degreasers).

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*Telephone conversation with Joseph Pokorny of Baron Blakeslee.

F.3 MAINTENANCE DEGREASING OF AIRCRAFT

The estimates of degreasers used in aircraft maintenance were obtained in the following manner: A detailed study of degreasing at Mather Air Force Base, California (Leung et al. 1978) an airport with lighted and paved runways, the use of 1 open topped vapor degreaser and 8 cold cleaners at the base. All similar airports were assumed to use the same number of degreasers. Airports not paved or lighted were assumed to utilize one cold cleaner in maintenance operations. Data on numbers and types of airports by region was obtained for 1975 from Table 3-S of the FMA Statistical Handbook and are presented in Table F1-6. The estimates of degreasing activities are highly speculative as data on only one airport was available and, further, it was arbitrarily assumed that all unpaved and/or unlighted airports only use one cold cleaner for maintenance.

F.3-1. DISTRIBUTION OF AIRPORTS BY REGION

	New England	Mid Atlantic	East North-Central	West North-Central	South Atlantic	East South-Central	West South-Central	Mountain	Pacific	TOTAL
# of Lighted and Paved Airports	120	228	498	483	450	257	529	315	399	3,279
# of Unlighted or Unpaved Airports	409	1,091	1,821	1,339	768	232	1,409	884	1,975	9,928
TOTAL	529	1,319	2,319	1,822	1,218	489	1,938	1,199	2,374	13,207

SOURCE: References 2 and 6.

F.4 AUTO REPAIR DEGREASING

The number of repair and maintenance facilities for each of the three years in Table F1-7 were taken from Service Job Analysis, Hunter Publishing Co., Chicago, Ill. (1978). Using data on state breakdowns of service stations, from Chilton's Motor Age Automotive Marketing Guide, Chilton, PA. (1976), regional shares for car and truck repair and maintenance facilities were derived from the Service Job Analysis information. Our estimates of degreasers per facility was reported in Alternatives to Organic Solvent Degreasing, Eureka Laboratories, Sacramento, Cal. (1978).

Table F4-1. ESTABLISHMENTS AND DEGREASERS IN AUTOMOTIVE AND TRUCK REPAIR MAINTENANCE

		Mid Atlantic	East North-Central	West North-Central	South Atlantic	East South-Central	West South-Central	Mountain	Pacific	New England	TOTAL
Number of Establishments Engaged in Automobile and Truck Repair and Maintenance	1973	45,430	67,658	37,301	59,206	26,111	45,355	20,512	42,651	17,775	362,000
	1975	45,179	67,285	37,095	58,897	25,967	45,105	20,399	42,416	17,676	360,000
	1978	43,423	64,668	35,652	56,588	24,957	43,351	19,605	40,766	16,989	342,000
Number of Degreasers in Automobile and Truck Repair and Maintenance	1973	59,059	87,955	48,491	76,968	33,944	58,962	26,666	55,446	23,108	470,600
	1975	58,733	87,471	48,224	76,566	33,757	58,637	26,519	55,141	22,979	468,000
	1978	56,450	84,068	46,348	73,564	32,444	56,356	25,487	52,996	22,086	444,600

F.5 ESTIMATED COSTS OF DEGREASING OPERATIONS

In any given year a firm will incur costs as a consequence of its degreasing activities. These costs will change as capital equipment requirements, manpower, energy use and solvent use change in response to NSPS's. This appendix presents estimates of the annualized costs of uncontrolled degreasing operations. The estimates are based on the assumption that no firm uses any of the controls recommended under the proposed NSPS's. This is an "unrealistic" assumption because some firms do utilize the operating procedures and control equipment recommended in the NSPS's. However, it is a useful assumption in the sense that it identifies the extreme pre-standard case. Any other assumption about the pre-standard situation would imply smaller NSPS economic impacts. In addition, given the imprecise nature of existing information on actual degreasing activities and the extent to which firms already comply with the proposed NSPS's, any other assumption would be equally arbitrary.

F.5.1 Cost Estimates

The annualized cost of any degreasing operation has two components: (1) an annual capital charge and (2) variable costs (including the cost of labor, energy, solvent and maintenance services). The annual capital charge is estimated on the basis of the following formula:

$$ACC = IC\left(\frac{1}{\sum_{i=1}^{L} (1+r)} + AOR + MSR\right)$$

where ACC = annual capital charge

IC = installed capital cost

L = lifetime of the asset in years

r = rate of interest

AOR = administrative overhead rate

MSR = maintenance service rate.

The formula is derived partially from the theory of present values. The present value of an annual income stream of one dollar over a period of L years is $\overset{L}{\Sigma}(1+r)^{-i}$. Letting the annual capital recovery charge be defined by the mnemonic ACRC, the expression ACRC $\cdot \overset{L}{\Sigma}(1+r)^{-i}$ may be defined as the present value of the stream of annual capital recovery charges. If the discounted sum of future returns to a given piece of capital equipment are to be sufficient to cover its costs to the firm, then the present value of the stream of ACRC's must be equal to the installed cost of capital; i.e., IC = ACRC $\cdot \overset{L}{\Sigma}(1+r)^{-i}$. Solving for ACRC, we have ACRC = IC/$\overset{L}{\Sigma}$1+r)$^{-i}$. Note that this formula is appropriate even if the firm finances capital from internal funds.

In this study all capital equipment is assumed to have a life of 15 years and the market rate of discount is taken to be 10 percent. Consequently the value of the capital recovery factor, $\overset{L}{\Sigma}(1+r)^{-i}$, is 0.131. The annual overhead and maintenance service charges are both assumed to be 4 percent of the value of the installed capital costs. Consequently, the value of the annual capital charge for any degreasing cost is given by the empirical formula:

$$ACC = IC(0.131 + 0.04 + 0.04) = IC\ (0.211).$$

Annual variable costs consist of payments for solvent, labor and energy.

F.5.1.1 Solvent Costs. It is assumed that in the base year (1976) the cost of solvent used in cold cleaning (mineral spirits) is 21¢ per kilogram. The cost of the solvent (trichloroethylene) used in both types vapor degreasers is assumed to be 45¢ per kilogram.

F.5.1.2 Energy Costs. Cold cleaners require a negligible amount of energy in their operations. However, the same cannot be said for open top and conveyorized vapor degreasers. In both operations solvent must be heated to create the vapor layer in which cleaning takes place and further heat must be applied to work loads to insure that effective vapor cleaning is achieved. Three types of heat may be utilized to create vapors and heat materials: (1) electricity, (2) gas and (3) steam. Industry sources indicate that usually electricity is used in the operation of open top vapor degreasers and steam in the operation of conveyorized degreasers. 1978 prices for electricity and steam are assumed to be $0.043 per KWH and $7.26 per 1000 kg of steam respectively. The electricity price was deflated by the BLS wholesale price index for electricity and the steam price by the BLS wholesale price index for coal to obtain estimates of 1976 prices for electricity and steam (see Table G2-1). Annual energy costs were calculated as the sum of payments for electricity and steam.

F.5.1.3 Labor Costs. The operation of degreasers requires labor. However labor costs will vary across SIC code industries because of wage rate variations and are thus industry specific. In this study hourly labor costs are measured by the average gross hourly earnings of production (non-supervisory) workers in each 3 digit SIC code industry for the base year, 1976. Data on hourly earnings are presented in Table F2-2. Total labor costs are estimated as number of manhours spent degreasing multiplied by costs (hourly earnings).

In order to calculate pre-NSPS annual degreasing costs it was necessary to identify representative degreasing operations for each of the three types of degreasers. Given the lack of survey data on degreasing operations, a number of degreasing equipment manufacturers were contacted by

Table F5-1. ENERGY COSTS, 1976 AND 1978

Year	BLS Producer Price Indexes[+]		Price of Electricity $1kWh	Price of Steam $11000 kg.
	Coal	Electricity		
1976	368.7	207.6	$ 0.035*	$ 6.29*
1978	432.4	252.8	$ 0.043[#]	$ 7.26[#]

[+] U.S. Department of Labor, Bureau of Labor Statistics, *Producer Prices and Price Indexes*.

[#] Source: MITRE.

*1976 Price = 1978 Price x $\frac{\text{1976 Price Index}}{\text{1978 Price Index.}}$

Table F5-2. LABOR COSTS, 1976*.

SIC Code		Gross Hourly Earnings of Production and Non-Supervisory Workers
254	Partitions and Fixtures	$4.82
259	Misc. Furniture and Fixtures	4.41
332	Iron and Steel Foundries	6.16
335	Nonferrous Rolling and Drawing	6.01
336	Nonferrous Foundries	5.22
339	Misc. Primary Metal Products	6.45
342	Cutlery, Hand Tools, and Hardware	5.22
343	Plumbing and Heating (except Electric)	4.86
344	Fabricated Structural Metal Products	5.34
345	Screw Machine Products, Bolts, etc.	5.24
346	Metal Gorgings and Stampings	6.10
347	Metal Services	4.43
348	Ordnance and Accessories	4.68
349	Misc. Fabricated Metal Products	5.31
351	Engines and Turbines	6.64
352	Farm and Garden Machinery	6.08
353	Construction and Related Machinery	6.03
354	Metalworking Machinery	5.94
355	Special Industrial Machinery	5.36
356	General Industrial Machinery	5.73
357	Office and Computing Machines	5.29
358	Refrigeration and Service Machinery	5.22
359	Misc. Machinery, except Electrical	5.57
361	Electric Distributing Equipment	5.10
362	Electrical Industrial Apparatus	4.97
364	Electrical Lighting and Wiring Equip.	4.87
366	Communication Equipment	5.62
367	Electronic Components and Accessories	4.11
369	Misc. Electrical Equip. and Supplies	5.65
371	Motor Vehicles and Equipment	7.10
372	Aircraft and Parts	6.45
376	Guided Missiles, Space Vehicles, Parts	4.43
379	Misc. Transportation Equipment	4.43
381	Engineering and Scientific Instruments	5.13
382	Measuring and Controlling Devices	4.73
39	Miscellaneous Industry	4.01
401	Railroads - Maintenance	6.88
458	Air Transport - Maintenance	6.46
753	Auto Repair	6.46
GIU		4.87

*Source: Department of Labor BLS; Employment and Earnings, Vol. 24, 3 March 1977. The figure used for 458 and 753 is the one presented for the 2 digit industry SIC-45 - General Transport. Specific earnings rates are not published by BLS for 458 and 753 because of data problems.

RTI and asked to describe typical plant degreasing equipment. This information was combined with a number of assumptions concerning capacity utilization rates to identify typical operations. These typical operations and the associated annualized capital charges, solvent costs, energy costs and manpower requirements are described in Tables F5-3 to F5-5. Total annual costs for each type of degreasing activity by SIC code industry are presented in Table F5-6. They include the annual capital charge, solvent costs, energy costs and labor costs. The estimates vary across industries because of the variations in labor costs discussed above.

Table F5-3. TYPICAL UNCONTROLLED DEGREASING OPERATION: COLD CLEANERS.

Cost Category	Assumptions	Cost Estimates
CAPITAL STOCK[*]	75% of all degreasers have a 15 gallon tank with a solvent-air interface area of 0.56 m^2. The 1978 Installed Capital cost of this degreaser is assumed to be \$339.00. 25% of all degreasers have a 65 gallon tank with a solvent-air interface area of 0.56m^2 1978 installed capital cost of this degreaser is assumed to be \$660.00.	Annualized Capital Charge of cold cleaners = \$[(0.75)339.00 + (0.25)660] x 0.211[¶] = \$88.46.
SOLVENT[+]	All machines are assumed to be left uncovered at all times. The vaporization rate of mineral spirits is assumed to be 0.188 kg/hr-m^2. Annual solvent loss from vaporization is thus: [0.75 x 0.56 + 0.25 x 0.58]m^2 x [0.188 kg/hr-m^2] x 24 hrs x 365 days = 494.94 kg. Each machine is assumed to process 20 work loads each day, 5 days a week, 52 weeks a year. Solvent loss from uncontrolled carryouts is assumed to be 14.2g per load. Solvent loss from carryout is thus: 0.0142 kg x 20 hr x 260 days = 73.840 kg. Waste solvent discarded by cold cleaner operators as unusable is assumed to be 50% of total solvent use; i.e., equal to solvent lost in carryout and through vaporization. Total solvent usage is thus 1137.5kg.	Annual Solvent Cost = 1137.5 kg x \$0.21 per kg = \$390.8.
ENERGY	Cold cleaners are assumed to use negligible amounts of energy.	0

Table F5-3 (Concluded).

Cost	Assumptions	Cost Estimates
LABOR+	Each machine is assumed to be operated for 2 hours each day, 5 days per week, 52 weeks per year. Total manpower requirements are thus 520 hours.	Annual Labor cost = 52 hrs x gross hourly earnings of labor

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*Data on typical cold cleaner operations provided to RTI by Larry Shields of Gray Mills Corporation in a telephone conversation on June 1, 1978.

#Installed capital labor data for 15 gallons or 65 gallons tank degreasers obtained from Gray Mill 1978 price lists 14K 10 PL-II and 65 PL-15.

†Data on solvent usage and labor usage provided by MITRE corporation.

¶0.211 is the estimated captial recovery, overhead and maintenenace charge coefficient.

§Data on solvent waste obtained from Appendix D of OAQPS Document, Control of Volatile Organic Emissions from Solvent Metal Cleaning, Appendix B, EPA-450/2-77-022.

Table F5-4. TYPICAL UNCONTROLLED DEGREASING OPERATION: OPEN TOP VAPOR DEGREASER

Cost Category	Assumptions	Cost Estimates (1976)
CAPITAL*	The typical open top vapor degreaser has a vapor interface area of 1.32 m^2. The tank holds 115 gallons of solvent. The 1978 installed capital cost of this degreaser was \$4766.5. The 1976 cost is assumed to be 20% less, or \$3972.08.	Annualized Captial Charge of an OTVD in 1976 = \$3972.08 x 0.211 = \$ 838.11.
SOLVENT +	The vaporization rate for solvent in an OTVD is assumed to be 1.82 kg/hr m^2. The degreaser is assumed to be left uncovered 8 hours per day, 5 days per week, 52 weeks per year. Solvent loss from vaporization is thus 1.82 kg/hr m^2 x 1.39 m^2 x 8 hrs x 260 days = 5262 kg.. The machine is assumed to be in use 6 hours per working day and carryout losses are 1.47 kg/hr m^2. Thus annual solvent loss from carryout is 1.47 kg/hr x (260 x 6 hrs) x 1.39 m^2 = 3187.5 kg. Annual Total Wash solvent, discarded as unusable, is assumed to be 22.5% of total solvent use. Thus total annual solvent use is estimated to be 10903 kg.	Annual Solvent Cost = 8449.5 kg x \$0.45 = \$4906.
ENERGY*+	The degreaser is assumed to be heated by electricity and its element to have a capacity of 24 kW It is assumed that element is operating at full capacity 8 hours per day, 5 days per week, 52 weeks per year.	Annual Energy Costs = (24 kW) (260 x 8 hrs) (0.035) = \$1747.20.

Table F5-4 (Concluded).

Cost Category	Assumptions	Cost Estimates (1976)
LABOR+	Each machine is assumed to be generated for 6 hours per day, 5 days per week, 52 weeks per year. Total manpower requirements are thus 1560 hrs. The 1978 installed capital cost of this degreaser is $4766.5. The 1976 cost is assumed to be 20% less, or $3972.08.	Annual Labor Costs = 1560 hrs x gross hourly earnings.

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*Data on typical OTVD capital equipment specifications, prices and price changes, and energy supplied to RTI by Richard Clements of Detrex, Ltd. in a telephone conversation on August 15th.

+Data on solvent usage and labor usage estimated by MITRE.

Table F5-5. TYPICAL UNCONTROLLED DEGREASING OPERATION: CONVEYORIZED VAPOR DEGREASER (CVD)

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Cost Category	Assumptions	Cost Estimates (1976)
CAPITAL[+]	The typical CVD is assumed to be a cross rod two dip degreaser with 12 rotating baskets. The 1978 price of the degreaser is $33,000 and the price of fixtures for each basket $900. The cost of the total unit is thus $41,600. The 1978 cost of this equipment is assumed to be 20% more than its 1976 cost. Thus the 1976 cost of the machinery is $34,667. Installation costs are incurred by the firm as a result of the extra building space needed for the CVD. The 1976 cost of space is estimated to be $30/sq. ft.[#] The space required by the CVD is estimated to be 109.3 ft.^{2}. Building costs are therefore $3280. The total installed capital cost is thus $37947.	Annual Capital Cost = $37947 x 0.211 = $8006.8....
SOLVENT*	Annual solvent vaporization for a cross rod CVD with a vapor interface area of 40 sq. ft. is estimated to be 23296 kg. Waste solvent, discarded as unusable, is assumed to be 15% of total solvent use. Thus total annual solvent use is estimated to be 27607 kg.	Annual Solvent Cost = 27407 kg x $0.54 = $12333.
ENERGY[+]	The typical CVD uses steam as a heat source at the rate of 340 lbs per hour. The machine is assumed to be utilized 8 hours per day, 5 days per week, 52 weeks per year. The annual total amount of steam used is thus 707200 lbs or 321455 kg.	Annual Total Energy Cost = $\frac{321455 \text{ kg} \times \$6.19}{1000 \text{ ks}}$ = $1990.

Table F5-5 (Concluded).

Cost Category	Assumptions	Cost Estimates (1976)
LABOR	The CVD is assumed to be operated 8 hours per day, 5 days per week, 52 weeks per year. Annual manpower requirements are thus 2080 hours.	Annual Labor Cost = 2080 hrs x gross hourly earnings.

[+] Data on typical CVD's supplied to RTI by Richard Clements of Detrex in a telephone conversation on August 15th.

*Solvent-usage calculated on the basis of solvent savings from the utiliztion of carbon adsorbers estimated by MITRE.

#The 1978 cost of building estimate identified by MITRE to be $35 sq. ft. was deflated by the Department of Commerce Composite Construction Index whose value in 1976 was 143.5 and March 1978 was 267.5.

Table F5-7. Annualized Costs of a Typical Uncontrolled Degreasing Operation By Type of Degreaser and SIC Code Industry.

SIC Code	Cold Cleaners	Open Top Vapor Degreasers	Conveyorized Vapor Degreasers
254 Partitions and Fixtures	2986	14710	32355
259 Misc. Furniture and Fixtures	2772	14071	31502
332 Iron and Steel Foundries	3682	16801	35142
335 Nonferrous Rolling and Drawing	3604	16567	34830
336 Nonferrous Foundries	3194	15335	33187
339 Misc. Primary Metal Products	3833	17256	35746
342 Cutlery, Hand Tools, and Hardware	3194	15335	33187
343 Plumbing and Heating (except Electric)	3006	14773	32439
344 Fabricated Structural Metal Products	3256	15522	33437
345 Screw Machine Products, Bolts, etc.	3204	15366	33229
346 Metal Gorgings and Stampings	3650	16708	35078
347 Metal Services	2782	14102	31544
348 Ordnance and Accessories	2912	14492	32054
349 Misc. Fabricated Metal Products	3240	15475	33375
351 Engines and Turbines	3932	17550	36141
352 Farm and Garden Machinery	3641	16576	34976
353 Construction and Related Machinery	3614	16598	34872
354 Metalworking Machinery	3568	16458	34685
355 Special Industrial Machinery	3266	15553	33479
356 General Industrial Machinery	3459	16130	34248
357 Office and Computing Machines	3230	15444	33333
358 Refrigeration and Service Machinery	3194	15334	33224
359 Misc. Machinery, except Electrical	3376	15881	33916
361 Electric Distributing Equipment	3131	15148	32938
362 Electrical Industrial Apparatus	3064	14945	32667
364 Electric Lighting and Wiring Equip.	3012	14789	32459
366 Communication Equipment	3402	15959	34019
367 Electronic Components and Accessories	2616	13588	30879
369 Misc. Electrical Equip. and Supplies	3417	16006	34081
371 Motor Vehicles and Equipment	4171	18268	37098
372 Aircraft and Parts	3833	17254	35746
376 Guided Missiles, Space Vehicles, Parts	2783	14102	31544
379 Misc. Transportation Equipment	2783	14102	31544
381 Engineering and Scientific Instruments	3147	15194	33000
382 Measuring and Controlling Devices	2938	14570	32168
39 Miscellaneous Industry	2564	13447	30670
401 Railroads - Maintenance	4057	17924	36640
458 Air Transport - Maintenance	3838	17269	35767
753 Auto Repair	3838	17269	35767

F.6 References for Appendix F

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